Interactive comment on "Introduction to the European Monitoring and Evaluation Programme (EMEP) and observed atmospheric composition change during 1972–2009" by K. Tørseth et al.

Response to interactive comments by the two referees,

by Tørseth et al, 26. April 2012 (kt@nilu.no)

We thank the two reviewers for their valuable comments to the manuscript. We found these helpful to improve the paper, and hope that our response will bring the paper to the quality required for publication in ACP. In the following, we repeat the reviewer's comments and respond point-by-point using underlined text.

Response to comments by Anonymous Referee #1

Received and published: 24 February 2012

General comments: This paper reviews the development of EMEP (the European Monitoring and Evaluation Programme) and presents some summaries of long-term trends, covering not only precipitation composition, but also particulate matter, ozone and precursors, heavy metals and persistent organic pollutants. The paper is well organised, and is clear to read. The breadth of coverage necessarily has to be at the expense of depth, and the analysis of the different measured components varies across components.

Although the long-term trends identified by the monitoring network are described, there was not a comprehensive comparison with other long-term European datasets, or with previously published analyses of European trends. This is perhaps the role of the other papers in this special issue, but it would have been useful to highlight (perhaps in a Table) previous publications that have used EMEP data to explore long-term trends.

We acknowledge that the EMEP data have been subject to a number of previous analysis to study European trends. Generally, these are either having a national perspective, or present region wide analysis covering some specific variables/topics. Giving an overview of and comparison with other trend studies was outside our scope of the paper, but we suggest to add reference to three important studies in the text.

These are:

p. 1754, l23: "The recent analysis on European PM trends (Barmpadimos et al.; 2012) using selected EMEP data corrected by meteorological variability show similar results as those presented here".

Barmpadimos, I., Keller, J., Oderbolz, D., Hueglin, C. and Prévôt, A. S. H.: One decade of parallel fine (PM2.5) and coarse (PM10–PM2.5) particulate matter measurements in Europe: trends and variability, Atmos. Chem. Phys., 12, 3189-3203, doi:10.5194/acp-12-3189-2012, 2012.

Start of Chapter 5.3: reference to Wilson et al (2010), see also below.

P1759, l11 (see below)

Colette, A., Granier, C., Hodnebrog, Ø., Jakobs, H., Maurizi, A., Nyiri, A., Bessagnet, B, D'Angiola, A., D'Isidoro, M., Gauss, M., Meleux, F., Memmesheimer, M., Mieville, A., Rouïl, L., Russo, F., Solberg, S., Stordal, F and Tampieri, F.: Air quality trends in Europe over the past decade: a first multi-model assessment, Atmos. Chem. Phys., 11, 11657-11678, doi:10.5194/acp-11-11657-2011, 2011.

As an introductory overview, the paper does a good job of alerting the community to the data that are available – but it would have been helpful in the abstract, as well as the text, to have been given details of how a prospective user of the data could access both the data themselves, but also the metadata that describe which parameters are available at which sites and over what time period.

On page 1738, l4, as well at page 1740 l20 gives reference to the data access (http://ebas.nilu.no) and one can also here find the description of metadata. To clarify this better for the reader we will add the following statement on p1740 l21: "The EMEP database web interface also offers additional meta information related to the individual data sets available in the database". We suggest to also add a link to the data source in the abstract: p1734, l2: "...comprehensive dataset (available at www.emep.int) which...."

The abstract could also usefully summarise the key conclusions, e.g. that sulphate is still the dominant ion in PM.

We will update the abstract to better reflect the key conclusions by adding "Despite the significant reductions in sulphur emissions, sulphate still remains the single most important compound contributing to regional scale aerosol mass concentration".

Specific comments:

p.1746, l25: the figure of 15% is misleading without a better description of "Europe". Data from the website cited for 2009 show SOx emissions from 'sea' areas as 34% of EU27 land-based emissions. Presumably the 15% refers to the whole EMEP domain in Europe.

Yes, 15% refers to the whole EMEP domain excluding the extended area of central Asia. It is also a matter of which Sea regions to include. We have chosen to use all (Baltic Sea; Black Sea, Mediterranean Sea, North Sea and the North-East Atlantic Ocean). The selection of emission region is not necessary comparable with the measurement region since the sites with long term trends are not evenly distributed in Europe. We propose to add an annex which describes how emissions data have been aggregated and refer to this on P1746, l25: "Table A2 describes how emissions data have been aggregated". Table A2 can ca found at the end of this interactive comment.

p.1747, l25: there is very little description of siting criteria for EMEP sites, and this could have been discussed earlier, as part of the development of the network from monitoring 'industrial' emissions linked to fossil fuel combustion, to a wider suite of measurements.

Referee #2 has also made specific comments regarding EMEP siting criteria and representativeness and we respond to both reviewers below.

p.1751, l5: the term "AirBase" is not defined. See comment above about making data available to readers.

We will alter the text to read " ...data reported to the European Air Quality Database - AirBase (http://www.eea.europa.eu/data-and-maps/data/airbase-the-european-air-quality-database-6) shows that ....

p.1755, l22: this statement is important and should appear in the abstract

We agree, and will add this statement to the abstract page (p1734, l8)

p.1763: reference could usefully be made to the recent paper by Wilson et al., Atmos. Chem. Phys. 12(1): 437-454 (2012)

Ch 5.3 starts with a short review of ozone trend papers based on EMEP data sorted with the most recent ones in the beginning. Thus we will add a ref. to the Wilson paper in the beginning of Ch 5.3.

Reference to be added: Wilson, R., C., Fleming, Z., L., Monks, P., S., Clain, G., Henne, S., Konovalov, I. B., Szopa, S. and Menut, L., Have primary emission reduction measures reduced ozone across Europe? An analysis of European rural background ozone trends 1996–2005, Atmos. Chem. Phys., 12, 437-454, doi:10.5194/acp-12-437-2012, 2012

Table A1 only contains site names and locations for the long-term studies. Other sites appear in some of the figures

We propose to alter the table title to specify that "the table lists the stations included in the trend analysis, while for location of other sites presented on maps we refer to http://ebas.nilu.no"

Figure 13: there are 13 sites shown in Fig 11 but only 10 shown here – why?

The reason for this is that the two sites lacking in Fig 13 (Kollumerward and Aucencorth Moss) didn't have sufficient amount of data for 2009 to satisfy the requirements chosen to be used in this figure/analyses.

Figure 13 & 16: refer to Table A1 for site identification.

This will be done in the revised manuscript

Technical corrections:

Abstract – line 2: early 1970s: ...which allows the evaluation of regional...

We agree and will alter the text as proposed

Line 12 (and elsewhere): 1990s

We agree and will alter the text as proposed

p.1736 l.18: "estimate cost efficient measures" is not clear – please reword whole sentence.

We suggest reformulate to read "...including projections to develop cost efficient measures".

l.20: ...human health...

We will alter the text as proposed

p.1739, l27: ...resolution are becoming available...

We will alter the text as proposed

p.1740, l21 : ...in this study are given...

We will alter the text as proposed

p.1741 l.3: the Mann-Kendall test is usually applied when data are NOT normally distributed

We will alter the text to read "data are not normally distributed"

l.12: .Sen's slope for first and last year: :.this is not clear, as the Sen's slope method should use all (pairs of) years from first to last. Please reword.

The Sen slope is based on all the years, the sentence refers to how we calculated the percent trends where we used the Sen slope estimate for the period in question (which gives a linear trend) and used the first year and last year in this time trend to calculate the percent changes, which is equivalent to use the slope and intercept. Therefore, this is maybe a bit unnecessary sentence since it is probably obvious. We thus suggest to delete this sentence ("For calculating the per cent change we have used the Sen's slope estimate for the first and last year in the trend analysis.") since the same is written in line 4-5. Further we will include more clarifying sentences in the next paragraph when we describe the trend estimates for the various periods (see next point)

l.16: should this read "1980-1990"? also in following line the sense (dates) is not clear – cf. Figure 3.

It should read 1980-2009. We used the Sen's slope for the whole 30 year period to calculate the 1980 value. We agree that the text is not clear on what has been done so we suggest to change to "In estimating the per cent change per decade for sulphur compounds (see Fig. 3), we first calculated an estimated value for the different years (1980, 1990, 2000 and 2009), and used these to calculate the percent change. Only sites with measurements for the whole period and in all media (gas, aerosol and precipitation) were included, fourteen in all. The year 1980 was defined as the Sen's slope estimate calculated from the period 1980–2009, while 1990 as the Sen slope estimate calculated from 1990–2009. 2000 however was calculated using the three year average between 1999–2001, while 2009 was calculated from the Sen's slope estimate for the 1990–2009 periods".

We also propose to add the following on p1741, l20: "data from 1990 only." and "In contrary to sulphur, there are relatively few sites with concurrent measurements of reduced and oxidized nitrogen in both air and precipitation, and for decadal trends we have chosen to use measurements from all long term measurement sites even if there are measurements in either air or precipitation only".

p.1742: should read "3 Major inorganic ions in precipitation" to distinguish from PM

This chapter presents major inorganic ions in precipitation, but does also present the inorganic gases like SO2, NO2 etc. It even presents aerosol chemical composition, but without in depth discussions related to the relative importance of these compounds to the aerosol mass concentrations (which is in chapter 4). We acknowledge thus that the overall titles do not perfectly match the content, but we believe it is preferable to keep the titles of chapters 3 and 4 unchanged.

p.1744 l.26: reword "quite variable in numbers" to express more clearly what is meant.

We suggest to reword to: “The results from these models show large differences in dry deposition flux estimates”

p.1747, l20: the trend in emissions is not influenced by changes in the monitoring network, although the reason for the discrepancy between emissions and measurements may be – reword.

We will alter the text to read: “...but the discrepancy between emissions and measurements may be influenced by changes in the station network”.

p.1766, l21: Harmens (OK in reference list)

Will be corrected in the text.

p.1767, l15: ...efficient removal installations...: Or ‘scrubbing’ installations.

We suggest to keep the term used in the referred paper (“dedusting installations”) so “deducting” was a typing error.

p.1772, l9: Figure 23d was not present in my copy.

We made a change in the illustration at a late stage without an according change in the text. By changing the text to refer to Fig 23 rather than 23d, the reference will be correct.

p.1774, l10: a bit pedantic, but ‘meteorology’ is the study of weather, and ‘weather’ would have been a better term to use.

We will change this

Table 3: last column should show – sign for all rows

Will be corrected in the text. We also propose to alter the last column to give “change pr year” rather than absolute change for the whole period. Below is a proposed new table (we have also written “2000(1)” to indicate that for some sites no data were available until 2001, this will be explained in the figure cation)

Trends 2000(1) - 2009								
		Sites with sign. trend		Per cent change		Annual average conc. ($\mu g/m^3$)		
Comp	Nr of sites	decrease	increase	Avg.	SD	2000(1)	2009	change pr year
PM_{10}	24	50%	0%	-18%	13%	16.4	13.5	-0.29
$PM_{2.5}$	13	46%	0%	-27%	12%	13.2	9.5	-0.37
PM_{10} - $PM_{2.5}$	11	18%	9%	-4%	24%	4.97	4.87	-0.01
$PM_{2.5}/PM_{10}$	11	27%	0%	-9%	9%	0.70	0.63	

Table 4: Sen’s…..

This typo (Senn’s) will be fixed to Sen’s

Response to comments by Øystein Hov, Referee #2

O. Hov (Referee), oystein.hov@met.no

Received and published: 15 March 2012

This is a valuable paper as it summarizes the trends and levels in the observed concentrations of all the chemical compounds included in the EMEP-programme since its inception around 1972 and to the present time (2009). It thus covers 4 decades of atmospheric measurements on a European scale at observational sites selected to represent regional rather than urban or suburban pollution levels, and the observations were made through times with very significant changes in emissions.

I think the paper should be published with minor revisions, and I suggest the authors consider some of the following general comments in revising the paper, as it may improve its message and information value.

1. The paper reviews observations taken over four decades, but the references are largely from the last decade. As the paper covers all the observational evidence from the whole programme period, the paper would gain from following the basic rules of referencing. The paper describing an original or basic result for the first time, should be referenced. Many of the older and original papers even have co-authors from NILU. For instance on p 10 line 13, sulphur and nitrogen deposition causing acidification and eutrophication is supported by references from 2006-2011. And the large reductions in emissions in Europe in the 1990s (p 14, line 7) is supported by references from 2004 and 2007. The paper would become more of a "legacy"-paper if the original papers were better referenced.

We agree that it is important to reflect original and basic studies in a paper having such a broad coverage as presented here. As our total number of references is already quite extensive, we propose to add a limited number of central papers in the chapters as follows:

P 1735, l20: added references: (…with emissions inventories (Semb, 1978) and model calculations (Eliassen, 1978), transboundary…)

Semb, A.: Sulphur emissions in Europe, Atmos Environ, 12, 455-460, 1978.

Eliassen, A.: The OECD study of long range transport of air pollutants: long-range transport modeling, Atmos Environ, 12, 479-487, 1978.

P1742, l12, add reference: "…four decades (Ottar et al., 1984, WGE, 2011…"

Ottar, B., Dovland, H. and Semb, A.: Long range transport of air pollutants and acid precipitation, Air Pollution and Plant Life, Ed. By Treshov, M. Wiley, p39-71, 1984.

P1756,l6, add reference: "…became available (Grennfelt and Scholdager, 1984; Grennfelt et al., 1989).."

Grennfelt, P and Scholdager, J.: Photochemical oxidants in the troposphere: a mounting menace, AMBIO, 13, 61-67, 1984.

P1764, l10: added reference: "…and the environment (Pacyna et al., 1984)."

Pacyna, J.M., Semb, A., Hanssen, J.E.: Emission and long-range transport of trace elements in Europe, Tellus, vol. 36b, 163-178, 1984.

2. The reasoning behind the spatial and temporal representativity and averaging of EMEP observations is presented only superficially (eg page 4). It could be argued more stringently why 24h averaging was used in the acidification and eutrophication work.

The referee refers to the description on page 4, but we would like to draw the attention to the more in-depth presentation on time resolution given on page 1738-1739 (i.e. pages 6-7). Here we have tried to introduce the EMEP monitoring strategy and the needs to spatial and temporal resolution. Specifically pp1739, l18-24 discuss the need for temporal resolution. In our opinion this discussion is balanced as compared to the other issues presented, and we suggest to keep this unchanged.

I also miss a somewhat more thorough discussion of the question of representativity of sites; the spatial covariance around a measurement point, etc. It is true that "Still the number of monitoring sites in Eastern Europe is inadequate" (p11 line 6-7), but this is a statement that could be better qualified. The EMEP monitoring strategy contains sentences with more information content than is provided here.

We propose to reformulate p1743, l6 to read "…Eastern Europe is considered inadequate (e.g. Tørseth and Hov, 2003; UNECE, 2009)"

Added reference: Tørseth, K, and Hov, Ø. (eds): The EMEP monitoring strategy 2004-2009. Background document with justification and specification of the EMEP monitoring programme, 2004-2009, EMEP/CCC-Report 9/2003, pp69, NILU, Kjeller, 2003.

To address the comments by both reviewers regarding site representativity we propose to add the following on p1738 l18: "Albeit the goal is to avoid that local sources unduly affect the observations, this can't be realized in an absolute sense. The major focus has been to avoid influence from significant industrial or transport related sources resulting in a network of rural sites (the siting criteria was originally based on recommendations outlined by WMO (1974)). Sites will to a varying degree be influenced by emissions from local and regional agricultural activities, various natural sources as well as other local sources (i.e ammonia, pesticides, carbonaceous material, mineral dust etc). A site which has a large spatial representativity for one given chemical compound may thus have low representativity for another variable. For an updated discussion on site representativity we refer to Henne et al (2010) and references therein. In general one can assume that EMEP sites in general do represent the regional scale atmospheric composition, but for more in-depth studies of individual datasets, we recommend to take additional metadata information into account".

Added reference: WMO: WMO operations manual for sampling and analysis techniques for chemical constituents in air and precipitation, World Meteorological Organization, Geneva, 1974.

3. There is a hierarchy of good regional observational networks in atmospheric chemistry worldwide, and I think the EMEP network ranks in the top because of its duration, maturity in terms of substances covered and reasoning behind it (the EMEP monitoring strategy and its link to the EMEP strategy), its governance (through CLRTAP with eg TFMM, TFIAM, TFRN, TFIAM, WGSR; SB and EB), and not least, due to its manual (SOP) for observations, and top-down quality control of the observational data including laboratory intercomparisons and field intercomparisons, all documented through EMEP reports that are reviewed and taken note of by the relevant parts of the EMEP structure. EMEP is a primary observational programme. It is set up, funded and operated on its own. The regional networks of GAW would be nonexistent without networks like EMEP, as GAW is not a primary network. Therefore EMEP is on the top of the hierarchy. In my view the text on pp 4, 7-8 could be strengthened

to show that EMEP actually stands out from the other networks, and in many cases is seen as a model for the others.

We appreciate these statements on the importance of EMEP and EMEP observations (actually, one of the main objectives of this paper is to present the EMEP activities in a way which may serve to document the views expressed by the referee). To further strengthen this, we propose to add the following statement on p1736, l15: "A major objective of this paper is thus to present and document the EMEP observation network and how it serves as a lead programme for addressing air quality, atmospheric composition change and transboundary fluxes of harmful substances".

4. Should "critical load" be defined? (p 13, line 1).

We propose to add in brackets the definition of critical load at the end of the sentence "(Critical load is defined as ""A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge")".

5. Harwell in the UK measured TSP at least from early 1970s (p 18 line 3).

We acknowledge that there may be additional time series at individual sites, but this study was limited to only address those data series which have been reported to the EMEP database.

6. Ozone site representativity could be discussed better than is the case on p 25, line 20.

We suggest to add the following on p1757 l21: "Ozone concentration near the ground is influenced by several factors, such as land use and topography, both affecting the surface dry deposition, as well as NOx sources in the vicinity leading to immediate ozone destruction. The importance of these processes normally varies through the day, following the diurnal cycle of the planetary boundary layer and the vertical mixing. Thus, the representativity of an ozone monitoring station does not only depend on the distance to emission sources but also to the "inhomogeneity" of the surrounding area. Areas with strong gradients in topography and land use will lead to a poorer representativity of the ozone measurements than e.g. a flat desert".

7. The nature of the observations used in the EEA ozone assessment (p 25 line 10) needs to be discussed. Are rural and urban/suburban observations from Airbase combined, or are the data "stratified" to detect trends in the larger spatial scale?

We assume this comment is relating to p1759 (p27 not p25). We suggest to add the following: "EEA's "Air Quality in Europe 2011"-report used all the EEA sites, including urban and suburban ones. Its focus is on describing the current air quality situation and has less attention to addressing trends. The EEA ozone trend study of 2009 used only sites classified as rural background in Airbase, and as a result of the fact that national agencies use their EMEP sites to also report for the European Commission Air Quality Directive, these datasets have a large overlap. No urban or suburban sites were included in the analysis and the study looked at single stations individually (mainly for the period 1995-2006) and included also results from regional scale photochemical modeling".

We suggest to replace the sentence at p. 1759, l11 ("Whereas the European anthropogenic emissions of NOx and NMVOC according to EMEP have been reduced by 31% and 46% (EMEP/CEIP, 2011), respectively, from 1990 to 2009, it seems difficult to identify clear trends from the observational data of ozone.")

The sentence will be replaced by this:

"The European anthropogenic emissions of NOx and NMVOC have been reduced by 31% and 46% (EMEP/CEIP, 2011), respectively, from 1990 to 2009. As these are the main precursors for ozone, one would expect clear changes in the European ozone concentration levels. However, due to the strong coupling between ozone and weather regimes and the substantial hemispherical background level, trends in ozone are often difficult to detect without very long time series. A recent study by Colette et al. (2011) showed very good agreement between observed and modelled NOx levels in Europe, whereas they comment that "O3 trends turned out to be much more challenging to reproduce". Nevertheless, they found that the suite of models included in their work were able to capture the trends at the majority of the sites."

8. The figure material includes some very useful new figures like Nos 1-3, 13, 16-18. The maps with the colored dots have been in use for a long time in EMEP publications, and one wonders if it is possible to enhance their information value by varying the size of the dot dependent on the representativity of the sites, for instance, or by some other innovation.

We appreciate the suggestion to develop alternative ways to display observed data on maps. There have been various attempts to develop more informative products, but we have not found alternatives which we find serves the purpose better than the current way (at least not without extending the effort in revising the paper significantly). We thus hope that the current approach can be accepted and that no changes are made to the map illustrations.

Suggestions for changes other than those commented by referees:

A reader has informed us of an error in figure 21 C. Here the legend is not visible for two of the sites, so we want to replace this with a new version where all legends are displayed.

In figure 22, we propose to add letters A and B to the charts to correspond with the figure caption

In figure 23 we suggest to replace "is" with "are" towards the end of the figure caption.

New Table A2:

Emission used for trend analysis, from EMEP/CEIP

	SOx				NOx				Nred				PM		NMVOC	
Area/Year	1980	1990	2000	2009	1980	1990	2000	2009	1980	1990	2000	2009	2000	2009	1990	2009
Albania	72	74	39	37	24	23	21	29	32	23	29	24	9	14	31	32
Armenia	141	86	11	26	15	60	31	24	25	24	13	17	0	0	95	41
Austria	360	74	32	21	246	212	206	187	52	69	65	64	23	20	284	123
Azerbaijan	15	615	162	85	43	171	104	91	25	68	37	53	6	4	376	238
Belarus	740	888	162	155	234	379	208	168	142	215	142	150	40	27	497	216
Belgium	828	361	172	76	442	382	334	213	89	112	85	67	33	16	305	108
Bosnia and Herzegovina	482	484	420	431	79	73	53	51	31	21	17	17	20	19	48	43
Bulgaria	2050	2007	918	658	416	363	184	165	144	144	56	51	59	34	214	146
Croatia	150	178	62	67	60	88	74	77	37	53	39	36	9	10	105	80
Cyprus	28	46	46	17	13	19	22	19	8.5	5	6	5	4	2	16	11
Czech Republic	2257	1876	264	173	937	742	321	251	156	157	74	73	28	20	374	151
Denmark	452	176	29	15	307	266	201	132	138	134	93	77	22	24	166	95
Estonia	287	274	97	55	70	74	37	29	24	26	10	10	21	19	71	36
Finland	584	259	79	59	295	299	210	153	39	38	37	37	40	38	221	111
France	3214	1333	632	303	2024	1829	1575	1117	795	787	802	744	381	270	2414	878
Georgia	230	43	7	23	121	64	30	51	97	36	20	26	3	2	151	228
Germany (DDR + FRG merged)	7514	5289	656	448	3334	2878	1911	1370	835	758	594	597	143	100	3584	1285
Greece	400	487	493	427	306	299	328	375	79	79	74	63	49	63	281	212
Hungary	1633	1011	486	80	273	276	185	167	157	124	71	68	26	28	252	128
Iceland	18	9	35	74	21	9	27	24	3	4	4	4	1	0	12	6
Ireland	222	186	140	33	73	119	138	90	112	114	121	108	12	9	111	52
Italy	3440	1795	749	231	1585	1945	1431	981	441	405	449	391	179	144	2023	1107
Kazakhstan																
Kyrgyzstan																
Latvia	96	97	16	4	83	69	36	29	38	47	13	16	23	28	73	61
Lithuania	311	263	43	36	152	158	47	65	85	82	25	28	0	0		0
Luxembourg	24	26	2	3	23	20	16	19	7	7	7	4	17	10	136	70
Malta	29[1)]	29	24	16	14[1)]	14	8	11	1[1)]	1	2	2	1	1	8	3
Netherlands	490	189	73	38	583	549	395	276	234	249	163	125	24	16	491	154
Norway	136	53	27	16	191	224	210	178	20	20	24	23	59	42	295	140
Poland	4100	3278	1511	861	1229	1581	838	820	550	511	322	273	135	120	832	615
Portugal	253	317	284	76	158	243	293	239	96	55	61	48	87	76	273	179
Republic of Moldova	308	175	13	7	115	131	27	29	53	61	25	27	2	6	123	36
Romania	1055	1310	760	460	523	527	297	247	340	289	206	188	116	123	517	432
Russia[2)]	7323	6113	2263	1723[2)]	3634	3600	2457	3350[2)]	1189	1204	663	602[2)]	0	0	0	0
Serbia (and Montenegro)	406	593	396	453	192	165	137	141	90	74	65	60	45	41	158	126
Slovakia	780	542	127	64	197	215	107	86	63	66	32	25	23	28	122	65
Slovenia	234	198	92	12	51	63	50	45	24	25	19	18	14	13	53	31
Spain	2913	2166	1419	403	1068	1247	1277	946	285	329	377	354	95	73	1135	671
Sweden	491	117	42	30	404	306	210	149	54	55	56	48	28	27	443	180
Switzerland	116	42	18	13	170	156	107	78	77	68	66	64	12	10	262	91
Tajikistan																
TFYR	107	110	90	113	39	46	39	33	17	15	14	7	9	9	21	28
Turkey	1030	1519	2000	1557	364	691	1118	1278	321	373	402	409	305	247	636	1320
Turkmenistan																
Ukraine	3849	3921	1599	1290	1145	1753	871	528	729	373	485	187	289	276	1053	275
United Kingdom	4852	3699	1253	397	2580	2932	1789	1086	361	373	333	288	103	70	2396	826
Uzbekistan																
NorthAfrica																
Asian																
Baltic Sea	228	168	188	122	352	236	276	327					22	17	8	13
Black Sea	57	45	56	69	86	62	81	97					7	8	2	4
Mediterranean Sea	1189	858	1070	1306	1639	1234	1564	1868					124	153	41	67
North Sea	454	361	443	288	648	508	649	771					52	39	18	29
Remaining NE Atlantic Ocean	901	384	494	614	1266	565	723	858					58	71	19	30
Natural marine	743[1)]	743	743	743												
Volcanic	2000[1)]	2000	2000	2000												
TOTAL	59592	46883	22737	16368	27810	27865	21253	19318	8095	7673	6198	5478	2759	2366	20748	10777
sum Parties	54020	42304	17743	11226	27786	27842	21232	15397	8095	7673	6198	5478	2497	2078	20659	10634
marine	2829	1816	2251	2399	55581	55648	42454	3921					262	288	88	143

1) Data for 1980 not availible, used 1990

2) Emissions from Russia is sum of Kaliningrad, Kazakhstan in the former official EMEP domain; Kola/Karelia; St. Petersburg/Novgorod-Pskov; Rest of the Russian Federation. Not comparable dataset for 2009, and used emissions from 2006 instead