

# BALTIC SEA ENVIRONMENT PROCEEDINGS

No. 39

## AIRBORNE POLLUTION LOAD TO THE BALTIC SEA 1986–1990



BALTIC MARINE ENVIRONMENT PROTECTION COMMISSION  
— HELSINKI COMMISSION —

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## PREFACE

Within the framework of the Baltic Marine Environment Protection Commission -the Helsinki Commission - monitoring data on airborne pollution have been collected since 1983 under the supervision of the Group of Experts on Airborne Pollution of the Baltic Sea Area (EC EGAP), according to the programme adopted by the Commission.

The data are collected at a number of monitoring stations in the Baltic region in order to assess the atmospheric pollution load to the Baltic Sea. The most recent assessment covering the period 1983-1986 have been reported in 1989 (HELCOM, 1989).

According to the decision of the Commission that a second pollution load compilation for the Baltic Sea should be compiled and published in 1992, EGAP has compiled the present report on the air pollution load covering the period 1986 - 1990.

The report has been prepared by an editorial group with Denmark acting as lead country and consisting of the following EGAP-members:

Niels Z. Heijdam (Chairman),  
National Environmental Research Institute, Denmark  
Vuokko Karlsson,  
Ministry of the Environment, Finland  
Sabine Mahling-Ennaoui and Jürgen Pankrath,  
Federal Environmental Agency, Germany

In this work the editorial group was assisted by the following HELCOM/EGAP consultants:

Ulf Pedersen,  
Norwegian Institute for Air Research, Norway  
Jørgen Saltbones,  
Norwegian Meteorological Institute, Norway.

In addition separate contributions were received from:

Sylvain Joffre and Virpi Lindfors,  
Finnish Meteorological Institute, Finland  
Gerhard Petersen,  
GKSS Research Center, Germany.  
Bernd Schneider,  
Institut für Meereskunde, Kiel, Germany.

The draft versions of this report have been considered and amended by relevant experts in the framework of EC EGAP prior to release. In the Helsinki Commission Secretariat the editorial work has been coordinated by the Environment Secretary, a.i., Eeva-Liisa Poutanen and the assistant, Teija-Liisa Lehtinen.

## OVERVIEW

### Summary

It is the purpose of this report to give the best possible estimate of the airborne pollution load of the Baltic Sea for the five year period 1986-1990. This pollution load has previously been shown to constitute a considerable fraction of the total marine pollution load, which has afflicted this very vulnerable sea in recent years.

Air pollution released from land based sources are often transported long distances before they are deposited either by dry or wet deposition. Thus also the surfaces of European waters are exposed to deposition of atmospheric pollutants.

The winds over the Baltic are often quite variable but on an annual basis the area is dominated by west-southwesterly winds. Many studies have shown that the main sources are the large industrial centres in central and eastern Europe.

The potential importance of atmospheric deposition to the Baltic Sea is revealed by the fact that the possibly polluted precipitation accounts for almost 50 % of the net water exchange which constitute only about 2 % of the oceanic volume.

In this report the Baltic Sea is divided into five sub-basins (shown in *Table 2.1.2 and Figure 2.1.1*). Where possible the airborne pollution load is estimated for each of these sub-basins, otherwise only for the total sea area of 415 000 km<sup>2</sup>.

The EGAP Monitoring Network consists of 26 land-based measuring sites situated in various types of rural areas so as to avoid the influence of local industrial sources. The main purpose of the monitoring network is to produce data that can be used for estimating the deposition of harmful substances to the Baltic Sea. That purpose can only be fulfilled if data reported by the contracting parties are of a high quality.

The monitoring program is based on measurements of routine minimum requirement compounds, additional experimental measurements and a quality assurance procedure.

The HELCOM/EGAP monitoring programme calls for determination of the precipitation concentrations of NH<sub>4</sub> and NO<sub>3</sub>, and, from 1990, Pb, Cd, Cu, Zn as a minimum requirement. The measurements of ambient air concentrations of pollutants is not part of the minimum requirement programme of EGAP and they therefore constitute a voluntary contribution.

The quality assurance protocol for monitored parameters used by the data host is similar to the EMEP Quality Assurance Plan and accordingly EGAP has initiated and participated in a number of intercalibration and intercomparison exercises.

The results showed that ammonium and nitrate are accurately determined but that minor deviations may occur because of the different designs of the precipitation samplers. The results from the trace metal intercomparison showed that at present the trace metal concentrations in precipitation should be viewed with some caution. This is of course also valid for any derived estimates. For these reasons it has been decided to restrict the use of trace metal results in this report to lead.

Precipitation concentrations from stations selected as representative of the various sub-basins are used to calculate basin average concentrations.

The results on ammonium and nitrate are used to calculate the concentration of total nitrogen, defined as the sum

$$[\text{Tot-N}] = [\text{NH}_4\text{-N}] + [\text{NO}_3\text{-N}]$$

The average value for this component is  $[\text{Tot-N}] = 1.34 \text{ mg/l}$ . The results show no trend for Tot-N over the five years 1986 - 1990 but geographically there is a clear concentration gradient from north to south.

The annual mean concentrations of lead in the Baltic Sea area have been found in the range from 4.8 to 9.1 µg Pb/l. The data do, however, contain some very atypical results that mask temporal or geographical tendencies expected from the diminishing use of leaded gasoline.

In general the estimation of the atmospheric pollution load on an ocean surface is difficult because data on airborne pollution concentrations as well as meteorological data such as precipitation are scarce or lacking for the open sea. To compensate for this it is necessary to resort to approximating methods.

Experimental estimates of the deposition of pollutants to the sea surface has to be based on extrapolation out over the sea of measurements performed at locations on the coast or on islands. However, only the wet deposition can be estimated in this way since the data from the mandatory monitoring programme are confined to precipitation concentrations.

It has not been judged possible to use these data to estimate the dry deposition. Nor are the ambient air data collected on a voluntary basis used for estimating the dry deposition since that can be handled more reliably by models. At any rate the dry contribution is expected to constitute only the minor part of the total deposition. Thus a recent experimental estimate for nitrogen deposition to the Baltic Sea yields an overall dry contribution of 15 %.

The wet deposition is estimated on the basis of the precipitation weighted mean concentrations measured at the stations. To calculate the sub-basin depositions the first step is to obtain the annual deposition flux, i.e. the area specific deposition. Here two different methods are used.

The first, experimental method relies exclusively on measurement data on concentrations and the precipitation recorded at the various coastal stations. The method presupposes that both the concentrations and the precipitation are representative also for the open sea and that is a crude approximation. The results of this method must therefore be viewed with some caution.

The second, hybrid estimation method relies on pollution measurements and both observed and calculated precipitation amounts. Model calculations are considered more reliable for estimating precipitation over the open sea than extrapolation of actual coastal measurements.

The hybrid fluxes are 10-20 % higher than the experimental ones. But for both types of fluxes there is a clear and consistent tendency for fluxes decreasing from about 1100 kg N/km<sup>2</sup> in the southern parts of the Baltic Sea, which are closer to the European air pollution sources, to lower fluxes around 650 kg N/km<sup>2</sup> in the north.

On the basis of the deposition fluxes the average wet deposition for 1986-1990 to the Baltic Sea has been estimated by the experimental and hybrid methods to be 314 and 330 kT N/yr, respectively.

The values for deposition in 1986 compare quite well with earlier estimates but the present estimates are lower in the north with about 20% but higher in the two southern basins with about 10 %. The results show that the wet nitrogen deposition to the Baltic Sea is divided almost equally between

oxidized and reduced compounds and that there is no discernible temporal trend during the latter half of the 1980s.

The wet deposition of lead is estimated as for the nitrogen compounds, i.e. on the basis of the precipitation weighted mean concentrations measured at the stations. The calculations proceed by the same two methods used for nitrogen. The data quality is not too good, however, and the average wet deposition of lead to the Baltic Sea in 1986-1990, estimated at 1000-1400 T Pb/yr, should be viewed with some caution.

As a third method for estimating the depositions one can resort to rely exclusively on model calculations. These calculations include the deposition based on fields for both precipitation and concentration. They can be considered quite reliable if good emission data are available. The model results also include dry deposition calculated as the product of airborne concentrations and deposition velocities.

The Lagrangian trajectory model of EMEP's MSC-W was one of the first to be developed for operational use. It is a one-layer model where concentrations are calculated as averages over the well mixed boundary layer. The model is being used on a routine basis for the calculations of transboundary pollution fluxes and deposition of sulphur and nitrogen compounds over Europe. The results show that the concentration and deposition fields are predicted reasonably well.

For routine calculations of horizontal transport of air pollution the MSC-E of EMEP has developed and tested a hybrid Lagrangian-Eulerian model which allows complex atmospheric processes to be included.

The EMEP models calculate concentrations and depositions of nitrogen compounds. Monthly averages are given in 36 emission and deposition domains representing countries and oceans. The models are able to keep track of the domain in which the pollution was emitted which makes it possible to allocate the deposition on the whole Baltic Sea to relevant emitter countries.

For nitrogen deposition it is found that the main contribution of 65 % comes from the Baltic Sea Countries, probably because of their proximity. Other prominent contributors are Great Britain, France and the Netherlands, which are all upwind of the predominant westerly winds in the Baltic and which are also among the major European emitters. Czechoslovakia is another major contributor.

The total dry and wet deposition of nitrogen to the Baltic Sea is found to be between 260 and 285 kT N/yr in the years 1988 to 1990. The nitrogen deposited is divided in the ratio 40/60 % among reduced and oxidized nitrogen.

Model calculations of trace element depositions have been carried out with a trajectory model with a similar structure as that of MSC-W. However, no physical or chemical transformation is assumed. The calculations have been restricted to lead for the period 1980-1985 because emission databases in the EMEP-grid for the metals is still in a very preliminary stage.

The result is that the total deposition of lead to the Baltic Sea is close to 1400 T Pb/yr. The calculations show that 70 % of the input is caused by the riparian countries around the Baltic Sea, the rest is due to long range atmospheric transport from other areas in Europe.

## Conclusion

The experimental and hybrid wet deposition estimates  $D_w^X$  and  $D_w^H$  and model values  $D_T^M$  for the total dry and wet deposition of nitrogen compounds to the Baltic Sea area in the period 1988-1990 are summarized in *Table I*.

**Table I.** Annual depositions of nitrogen to the Baltic Sea (kT N/yr).

Depos.type	1988			1989			1990		
	Red.N	Ox.N	Tot-N	Red.N	Ox.N	Tot-N	Red.N	Ox.N	Tot-N
Wet: $D_w^X$	168	164	331	160	136	296	183	166	349
Wet: $D_w^H$	171	167	338	174	152	325	184	165	349
Total: $D_T^{M-W}$	116	169	285	104	158	261	107	173	280
Total: $D_T^{M-E}$		163			147				

It is seen that the wet depositions of nitrogen estimated by both the experimental and the hybrid methods are larger than the total dry and wet deposition calculated by the EMEP-models. This discrepancy is most pronounced for reduced nitrogen (ammonia) where the measurements in agricultural areas may lead to overestimates of the area-wide, oceanic concentrations. In addition, the model calculations for reduced nitrogen are based on unofficial figures for ammonia emissions that have not been updated since 1985.

The assessment of the deposition of nitrogen to the Baltic Sea can be summarized as follows:

The experimental and hybrid values  $D_w^X$  and  $D_w^H$  probably overestimate the wet deposition of reduced nitrogen.

The model values  $D_T^M$  probably underestimate the same quantity.

For oxidized nitrogen the deposition estimates  $D_w^X$  and  $D_w^H$  are probably overestimates whereas the model estimate  $D_T^M$  that includes dry deposition is considered fairly realistic.

A reasonable estimate for the total deposition of nitrogen to the Baltic Sea in the latter half of the 1980's thus seems to be

300 000 ± 30 000 Tonnes N/yr

The estimates of annual lead depositions to the Baltic Sea as extrapolations of measurements and as model calculations by GKSS are summarized in *Table II*. The variation of up to 60 % among these results is considerable. The reasons for that are on one hand that the quality of the measurement data is not good enough and that in some cases quite crude approximations have been used to extrapolate measurement results out over the sea and on the other hand that the emission inventories used for model calculations are in need of improvement and updating.

**Table II.** Annual deposition of lead to the Baltic Sea (T Pb/yr).

Period	Type	Ref.	T/yr
1986-1990	$D_w^x$ , wet	This work	965
1986-1990	$D_w^H$ , wet	This work	1285
1986-1989	$D_t^x$ , total	Schneider, 1988	1600
1987	$D_t^x$ , total	Schneider, 1988	1030
1985	$D_t^M$ , total	Petersen et al., 1989	1400

The assessment of the deposition of lead to the Baltic Sea can be summarized as follows:

The experimental and hybrid values for wet depositions,  $D_w^x$  and  $D_w^H$ , are very uncertain.

The experimental values for total deposition,  $D_t^x$ , are probably overestimates.

The model value for total deposition,  $D_t^M$  is probably an underestimate.

**A reasonable estimate for the total deposition of lead to the Baltic Sea in the latter half of the 1980's thus seems to be**

$$1300 \pm 250 \text{ Tonnes Pb/yr}$$

## 1. INTRODUCTION

*The special characteristic of the Baltic Sea lies in the fact that actually it is neither an ocean nor a lake, but a large brackish water basin with very stable density stratification. The sea is also exceptionally shallow with a mean depth of about 60 m and only connected to the world ocean through the narrow Danish Straits; thus it has a more stagnant than through-flow character. This regional nature, together with the weak circulation and the low salinity of its water make the Baltic Sea extremely vulnerable to pollution.*

This short statement excellently describes the precarious state of the Baltic Sea Marine Environment (Voipio, 1981). It makes the need to monitor all pollution pathways to the Baltic Sea quite obvious.

The air pollution load to the Baltic Sea has previously been shown to constitute a considerable fraction of the total pollution load, which has afflicted this very vulnerable sea in recent years (HELCOM, 1989). Thus, the total nitrogen load to the Baltic Sea in the first half of the 1980s was estimated in the First Baltic Sea Pollution Load Compilation (HELCOM, 1987) at 940 kT N/yr. The atmospheric inputs were estimated at about 410 kT N/yr and the remainder 530 kT N/yr derived from riverine and similar inputs. It is the purpose of this report to give the best possible estimate of the airborne pollution load of the Baltic Sea for the five year period 1986-1990. In this context the load is defined to be the deposition to the surface of the Baltic Sea of atmospheric pollutants measured in the mandatory HELCOM/EGAP monitoring programme.

Several different methods for estimating the depositions are used in this report. The restriction to the pollutants of the mandatory programme entails, however, that only wet deposition by precipitation scavenging can be estimated using these data whereas dry deposition estimates have to be obtained by other means.

Some experimental estimates of the dry deposition of nitrogen have been taken from a research project carried out by the Finnish Meteorological Institute (Lindfors et al., 1991). Some of the deposition results for trace metals have similarly been supplied from a research project at GKSS, Germany (Schneider, 1988).

Other estimates for atmospheric depositions are based on long-range numerical models that describe the continent-wide emission, dispersion, transformation and deposition of atmospheric pollutants. In contrast to the experimental methods the model results comprise both dry and wet deposition. As the transport of air pollution knows no borders it is necessary to take account of all significant air pollution sources in Europe. Such models have been constructed and applied in the European cooperative effort EMEP under the UN-ECE Convention on Transboundary Air Pollution in Europe with which HELCOM has established close cooperative links.

The estimates of the pollution deposition to the Baltic Sea are given as a result of this cooperation. By special agreement the EGAP monitoring data are stored at EMEP's Chemical Coordinating Center (CCC) at the Norwegian Institute for Air Research, NILU. The nitrogen model results have been supplied by EMEP's Meteorological Synthesizing Centres West (MSC-W) at the Norwegian Meteorological Institute in Oslo and East (MSC-E) at the Institute of Applied Geophysics, Moscow. The results on trace metals have been taken from a research project of the German Federal Environmental Agency carried out by the GKSS Research Center (Petersen et al., 1989).

## 2. THE BALTIC SEA

### 2.1. Geography

The Baltic Sea is an enclosed sea area, a bay of the Atlantic ocean, extending over the latitudes 54°N-66°N and longitudes 10°E-30°E. Hence the Baltic Sea is a northern and relatively cold sea. The main characteristic data on the Baltic Sea according to Helsinki Commission (1986) is given in *Table 2.1.1*.

**Table 2.1.1.** The main characteristic data of the Baltic Sea.

Region	Discharge area km <sup>2</sup>	Sea area km <sup>2</sup>	Volume km <sup>3</sup>	Max. depth m	Mean depth m
Bothnian Bay	269 950	36 260	1 481	171	41
Bothnian Sea	229 700	79 257	4 889	294	62
Gulf of Finland	419 200	29 498	1 098	123	37
Gulf of Riga	127 400	17 913	406	51	23
Baltic Proper	568 973	209 930	13 045	459	62
The Sound + Belts	27 360	20 121	287	38	14
Kattegat	78 650	22 287	515	109	23
Baltic Sea	1 721 233	415 266	21 721	459	52

The discharge areas of the Baltic Sea and its sub-basins are the land areas drained by rivers flowing into the Baltic.

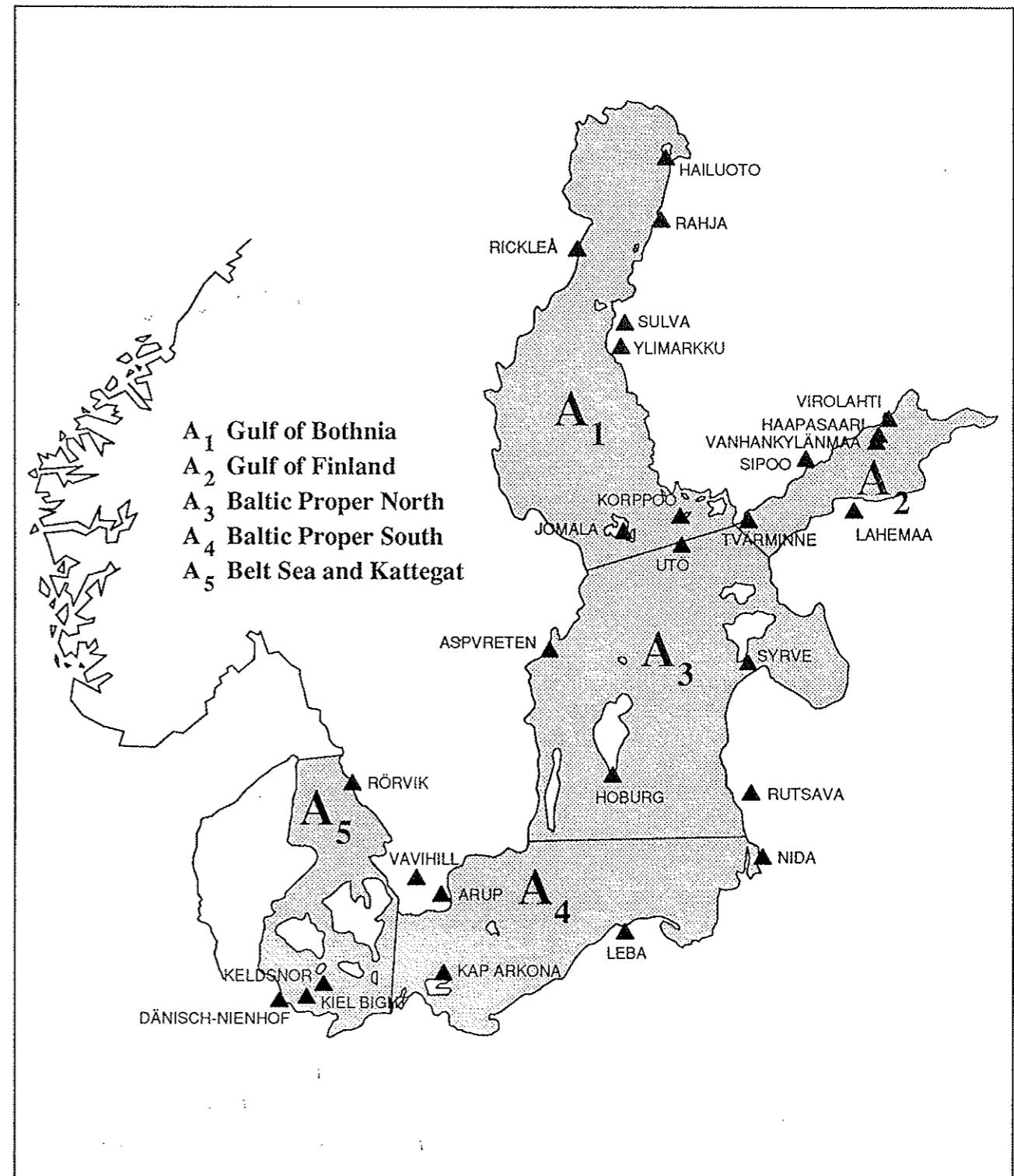
In this report the Baltic Sea is divided into the following sub-basins.

**Table 2.1.2** The sub-basins of the Baltic Sea.

A <sub>1</sub> The Gulf of Bothnia	115 517 km <sup>2</sup>
A <sub>2</sub> The Gulf of Finland	29 498 km <sup>2</sup>
A <sub>3</sub> Baltic Proper, North	166 842 km <sup>2</sup>
A <sub>4</sub> Baltic Proper, South	61 000 km <sup>2</sup>
A <sub>5</sub> Belt Sea and Kattegat	42 408 km <sup>2</sup>
A <sub>0</sub> Baltic Sea	415 266 km <sup>2</sup>

The geographical extent of the sub-basins are shown in *Figure 2.1.1*.

**Figure 2.1.1.** Division of the Baltic Sea into sub-basins and the EGAP monitoring sites.



The airborne pollution load is estimated only on this sea area of 415 000 km<sup>2</sup> whereas the atmospheric pollution load coming via the much larger discharge area is not included in the evaluations. This is because the air pollution deposited on the discharge land areas will eventually enter the draining rivers and become part of the freshwater discharge to the Baltic.

The water balance of the Baltic Sea over an area of 372 858 km<sup>2</sup> (with the exclusion of Belt Sea and Kattegat) is, according to the Helsinki Commission (HELCOM, 1986), characterized by the quantities shown in *Table 2.1.3*.

**Table 2.1.3.** Water balance parameters for the Baltic Sea, sub-basins A<sub>1</sub>-A<sub>4</sub> (km<sup>3</sup>/yr).

	30-year averages km <sup>3</sup> /yr
Precipitation	223.6
River inflow	436.1
Gross fresh-water input	659.7
Evaporation	183.9
Net fresh-water input	475.8
Net outflow	471.1
Storage difference	4.7

It can be seen that the permanent circulation of the Baltic Sea water is very weak, only about 2 % of the oceanic volume and it is clearly related to the excess of fresh-water supply. The current velocities are of the order of a few cm per second in the surface layer and less than one cm per second in the deeper layers. The wind-driven motions of the water are stronger, however, and a clear correlation has been observed between the wind and current velocities especially in the surface layers of the sea (Kullenberg 1981). Thus the wind is an important factor in creating vertical and horizontal mixing of water and pollutants occurring in the water.

The potential importance of atmospheric deposition is revealed by the fact that precipitation accounts for about 35 % of the gross fresh-water input to the Baltic and for almost 50 % of the net in- and outflows.

## 2.2. Climatology

The monthly averages of the air temperature T<sub>a</sub> and water temperature T<sub>w</sub> during the years 1980-1986 at three locations in the Baltic Sea are shown in *Figure 2.2.1. a-b*. The air temperature data are based on 3-hrs meteorological data, while water temperature statistics are taken from monthly reports (Weather and Water) of the Swedish Meteorological and Hydrological Institute. The locations are the stations of Utö in the Finnish Archipelago, Hoburg on the island of Gotland, and Kap Arkona on the German coast, roughly representing conditions in the Northern, Central and Southern Baltic, respectively. We see that the six curves are in phase with a summer maximum in July-August while the winter minimum occurs in February in the air and in March in the water. The geographical gradient is stronger in winter than in summer in both media.

The mixing of air pollutants, i.e. their vertical distribution in the lower atmosphere, and dry deposition rates are closely coupled to the turbulence intensity which depends strongly on the hydrostatic stability in the atmospheric boundary layer. The stability conditions are determined by the air-water temperature difference  $\delta T = T_a - T_w$ . The annual trend of this difference is depicted in *Figure 2.2.2*. Note that  $\delta T$  is positive in spring-summer thus implying stable conditions, i.e. a low boundary layer and small deposition velocities. During the rest of the year (autumn-winter), the conditions are preponderantly unstable yielding a deeper boundary layer and higher deposition velocities.

Almost every winter parts of The Baltic Sea are covered by ice see *Figure 2.2.3*. The northernmost part of sub-basin A<sub>1</sub>, the Bothnian Bay, is always covered totally by ice, and very frequently this happens also in the near-coast waters in the Bothnian Sea and the Gulf of Finland. Even off the shores of Kattegat ice is occurring approximately every second winter. Usually the open sea area of the southern Baltic Proper is open in winters. Due to the low salinity of the surface water (1-4 ‰ in the north and 8 ‰ in the south) ice is formed most easily in the north (Climatological Ice Atlas, 1982).

The influence of the ice cover on the deposition mechanisms are discussed in the next section.

Figure 2.2.1. Air and Sea Surface Temperatures 1980-1986 at three locations in the Baltic Sea.

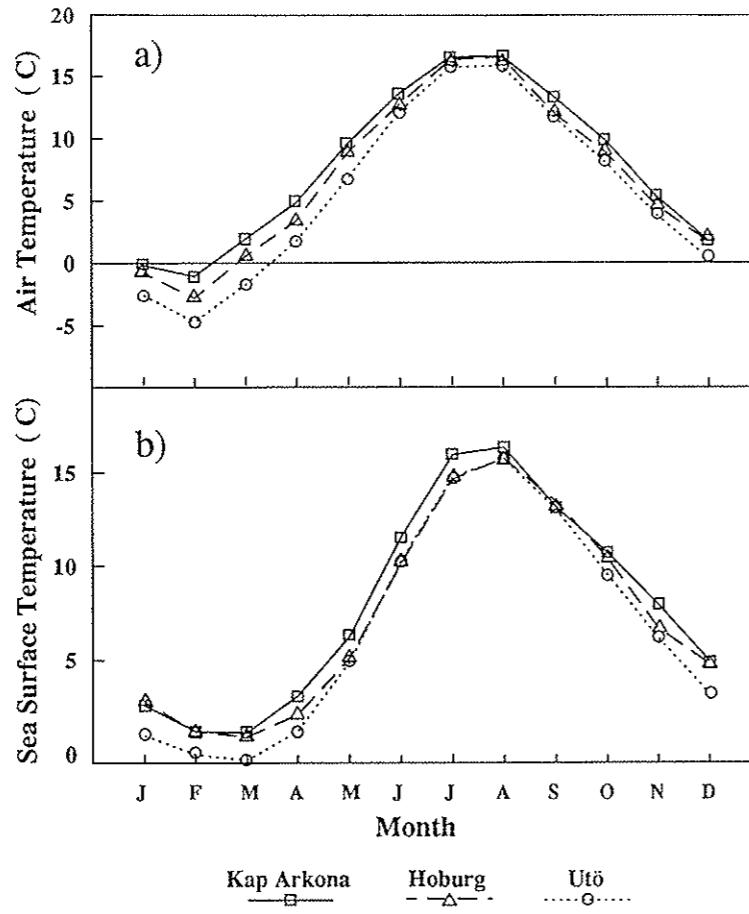


Figure 2.2.2. Temperature difference between air and water 1980-1986.

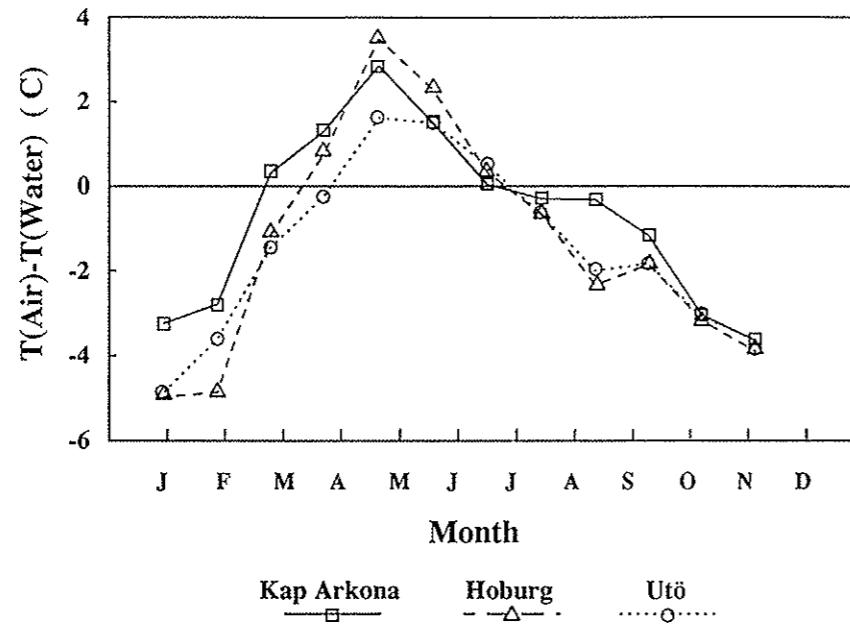
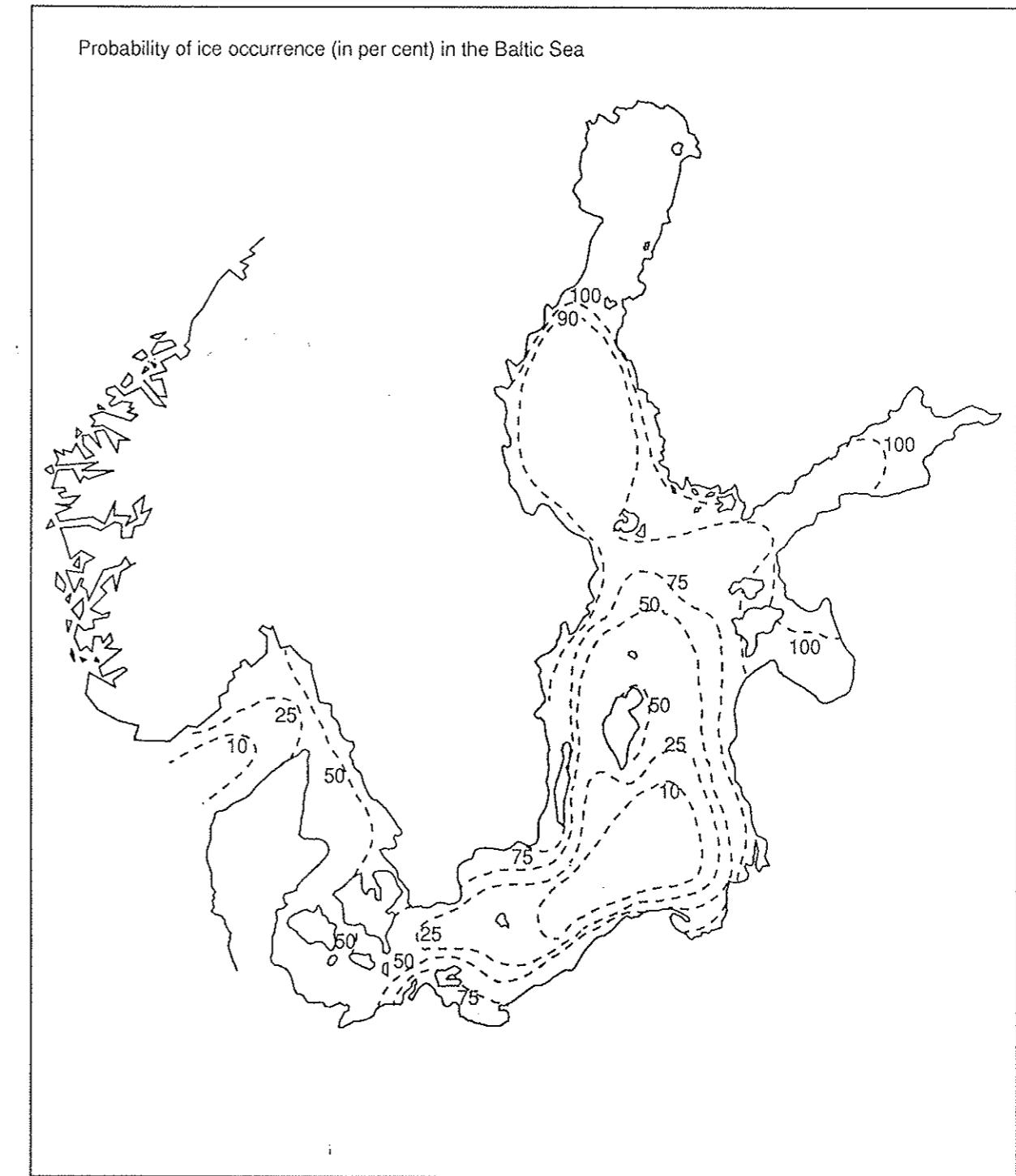


Figure 2.2.3. Probability of Ice Occurrence in per cent. (Climatological Ice Atlas, 1982).



### 2.3. Air Pollution Transport and Deposition

Air pollution released from land based sources are often transported long distances before they are deposited either by dry or wet deposition. Thus also the surfaces of European waters are exposed to deposition of atmospheric pollutants and it has in recent years been recognized that this atmospheric contribution may constitute a considerable fraction of the total marine pollution load.

For trace substances of concern in the Baltic Sea ecosystem consideration must be given to the atmospheric transport on spatial scales ranging from local (a few hundred m to several km) to long-range (hundreds to thousands of km). Meteorological studies as well as the geographical concentration pattern of air pollutants have shown that the main sources are the large industrial centres in central and eastern Europe. The development of emission data bases for Europe has made it possible to relate atmospheric pollutant concentrations over the Baltic to their sources. Various techniques such as enrichment factors and sector analysis as well as atmospheric dispersion models have been used to assess the contribution of emissions from foreign sources to atmospheric concentrations measured in the Baltic Sea area.

Removal processes of gaseous and particulate air pollutants from the atmosphere to sea-surfaces can be grouped into two categories: **wet and dry deposition**.

**Wet deposition** takes place by uptake of gases and particles by cloud droplets, followed by precipitation (rain-out) or by scavenging of gases and particles by falling raindrops or snowflakes (washout). The rate of wet deposition over the Baltic can be expected to show a seasonal dependence because precipitation intensity varies during the year. Wet deposition is also a function of the size distribution and chemical composition of the rain or cloud droplets, the diffusion constant and Henry's constant of the gases involved. For particles the scavenging is highly dependent on particle size.

**Dry deposition** is influenced by a multitude of physical and chemical factors. The significance of these factors varies depending on the physicochemical characteristics of the pollutant, the meteorological conditions of the atmosphere and the properties of the surface. Dry deposition processes over the ocean differ from those over land because of the unique character of the surface and the temperature difference between the air and the ocean. This is of special importance for the Baltic Sea, which is almost every winter partly covered by ice.

The presence of an ice cover on the sea surface has two types of influence:

- one direct effect connected with the ability of the surface to uptake depositing gases and particles, and
- one indirect effect in the sense that stability conditions in the atmosphere are drastically altered when the sea surface is ice-covered.

The transfer of **particles** to the sea surface is not affected by the presence of the ice cover since particles are equally retained by the water surface or the ice/snow cover which prevents resuspension. On the other hand, soluble gases like SO<sub>2</sub>, NH<sub>3</sub> and HNO<sub>3</sub> have a high deposition velocity to the water surface (typically 0.5 - 1.5 cm/s) but probably deposit much slower to an ice/snow surface. Naturally, the deposition velocity rises again if the snow surface is wet or is melting.

As described earlier the stability conditions over open water are unstable in winter, thus enhancing the deposition through increased turbulence. Eventually, as soon as the sea surface is closed by the presence of ice, the surface temperature is driven by thermal molecular processes in the ice/snow cover and thus depends on the changing air temperature in the same way as overland situations. During the dark part of the winter, this mainly implies stable conditions and a low deposition

velocity. As the daily cycle becomes more pronounced in February-March stably stratified conditions prevail at night and unstable conditions during the day. Also the ice cover may exist until May. High wind and/or overcast situations generally imply near-neutral stability conditions whatever the type of surface.

In general the estimation of the atmospheric pollution load on an ocean surface is difficult because data on airborne pollution concentrations as well as meteorological data such as precipitation are scarce or lacking for the open sea. To compensate for this it is necessary to resort to approximating methods.

#### 2.3.1. Precipitation over the Baltic Sea.

Experimental estimates of the deposition of pollutants to the sea surface has to be based on extrapolation out over the sea of measurements performed at locations on the coast or on islands. However, only the wet deposition can be estimated with some confidence since the data from the mandatory monitoring programme are confined to precipitation concentrations. It has not been judged possible to use these data to estimate the dry deposition, but that is expected to constitute only the minor part of the total deposition.

If estimates for atmospheric wet deposition are to be obtained information on occurrence, magnitude, and distribution of precipitation is necessary. Whereas extrapolation of concentration values in precipitation at coastal sites may be carried out with some confidence, the estimation of precipitation over the sea is quite uncertain because meteorological conditions may differ considerably from those prevailing at a coastal site. This method has, nevertheless, been used as one of the methods for estimating the precipitation and deposition over the Baltic Sea. It is presented and discussed in more detail in Appendix A.

The experimental precipitation estimates for the sub-basins are calculated as the mean of the annual precipitation measured at the stations in the basin.

$$P_b^X = \sum P_s / S_b,$$

where the sum is over the number  $S_b$  of stations in the basin. For the whole Baltic Sea the area weighted average is used

$$P_b^X = \sum P_b^X A_b / \sum A_b,$$

where the sum now runs over the five sub-basins. These experimental estimates, labelled accordingly with a superscript of X, are shown in *Table 2.3.1*.

**Table 2.3.1.** Experimental precipitation estimates  $P_b^x$  in mm for the Baltic Sea 1986-1990.

Sub-basin	Area km <sup>2</sup>	1986	1987	1988	1989	1990	1987-1990 Average
A <sub>1</sub> Gulf of Bothnia	115 517	603	532	582	544	585	561
A <sub>2</sub> Gulf of Finland	29 498	621	592	559	581	628	590
A <sub>3</sub> Baltic Proper, North	166 842	604	500	608	511	753	593
A <sub>4</sub> Baltic Proper, South	61 000	523	528	588	531	673	580
A <sub>5</sub> Belt Sea and Kattegat	42 408	521	673	769	574	733	687
A <sub>0</sub> Baltic Sea	415 265	585	537	611	535	683	592

Alternative methods of estimation include the use of numerical weather prediction models. Such models can be used with some confidence to estimate the average precipitation field over the sea, and this field can then be used in conjunction with extrapolated concentrations. This second hybrid method for wet deposition is also applied in the report.

Finally, one can resort to rely exclusively on model calculations. These calculations include the deposition based on fields for both precipitation and concentration. The latter can be considered quite reliable if good emission data are available. The model results also include dry deposition calculated as the product of airborne concentrations and deposition velocities.

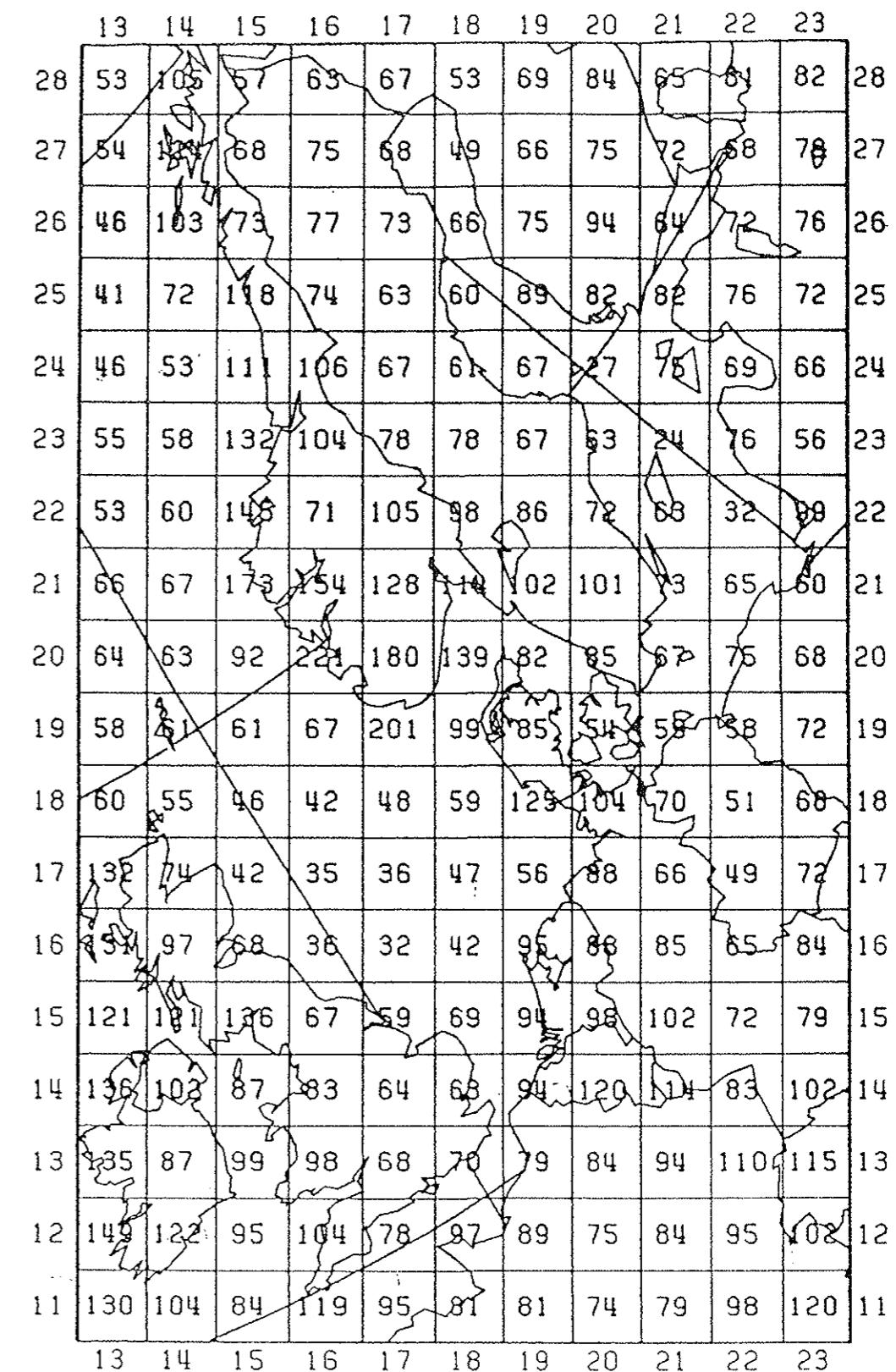
As a basis for the assessment of precipitation conditions over the sea the 6-hourly precipitation fields from the archive at MSC-W have been used to produce monthly and yearly accumulation fields. These fields are based on SYNOPS (observation) for land and islands in the area. For more open sea areas, model calculations from the numerical Limited Area weather prediction Model (LAM150) are used. These precipitation fields are the ones ordinarily used in the MSC-W model calculation for sulphur and nitrogen compounds (Iversen et al., 1990). Due to the lack of observations over the sea the model calculations presently constitute the best available estimates for precipitation over the ocean. An example is shown for 1988 in Figure 2.3.1. Since they are based on a combination of observational and models results they are of a hybrid nature and will be denoted  $P_b^H$ .

For the year 1986, a full data coverage was not available, and this year is therefore not included in these calculations. To facilitate comparisons the averaging period for  $P_b^x$  and  $P_b^H$  has been limited to the four years 1987-1990.

By inspecting the yearly precipitation maps as the one presented in Figure 2.3.1. (1988) an area-weighted mean value for each of the 5 subregions at the Baltic Sea has been calculated. The hybrid estimates,  $P_b^H$ , are shown in Table 2.3.2. together with the average ratio of hybrid to experimental estimates.

The hybrid estimates are presented with the reservation that the LAM150 model appears to give less precipitation over sea than observed over land. Thus the area with minimum precipitation (A<sub>3</sub>-Baltic proper north) is most influenced by LAM150 model calculations, whereas other areas are more strongly influenced by observations from the surrounding land areas.

**Figure 2.3.1.** Model estimates for the distribution of precipitation in 1988.  
Units: cm.



**Table 2.3.2.** Hybrid precipitation estimates  $P_b^H$  in mm for the Baltic Sea 1987-1990.

Sub-basin	Area km <sup>2</sup>	1986*	1987	1988	1989	1990	1987-90 Average	$P^H/P^X$
A <sub>1</sub> Gulf of Bothnia	115 517	635	606	623	631	679	635	1.13
A <sub>2</sub> Gulf of Finland	29 498	729	684	706	732	792	729	1.24
A <sub>3</sub> Baltic Proper, North	166 842	523	499	559	457	575	523	0.88
A <sub>4</sub> Baltic Proper, South	61 000	679	684	665	625	741	679	1.17
A <sub>5</sub> Belt Sea and Kattegat	42 408	747	701	758	664	865	747	1.09
A <sub>0</sub> Baltic Sea	415 265	614	590	623	571	673	614	1.04

Data from MSC-W archives.

\*) For 1986 the average values of  $P^H$  for 1987-1990 have been used.

On the basis of the hybrid estimates in *Table 2.3.2.* the following tentative conclusions can be reached:

- I: There is a tendency of more precipitation in the southern/western part of the area than in the middle and northern part.
- II: The inter-annual variability is largest around Denmark (area 5) and in the central part of the Baltic (area 3).
- III: The precipitation over the sea seems to be less, about 60-80 %, than over the surrounding land area.
- IV: The ratios of the two types of estimates  $P^H$  and  $P^X$  show that the hybrid estimates are larger than the experimental ones by 10-20 %, with the exception of sub-basin 3.

Considering that the hybrid estimates are the more reliable ones this difference reveals that the siting of the monitoring stations is critical for estimation of the precipitation.

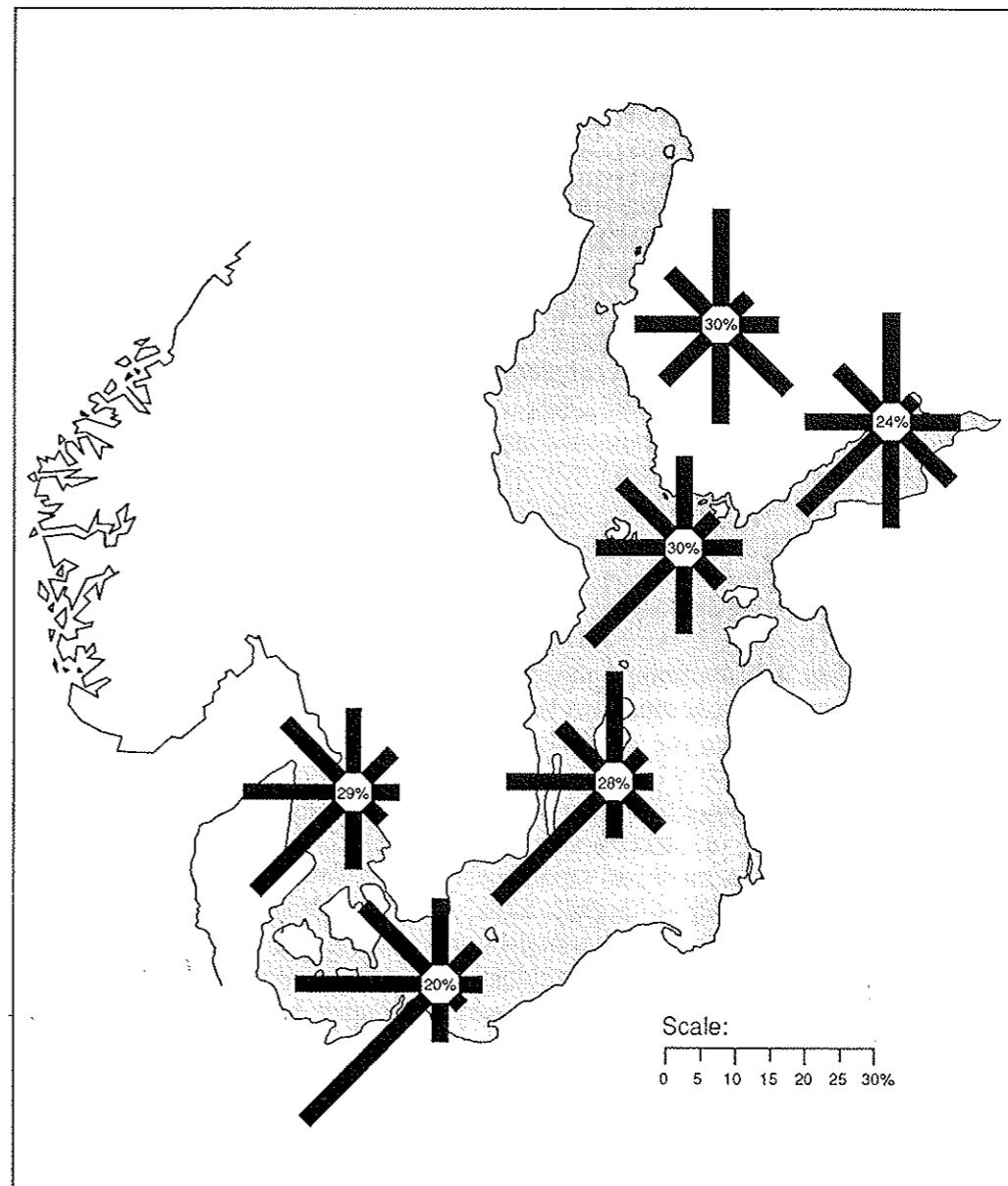
To facilitate comparisons of the various methods of estimation without losing the year 1986 completely the missing hybrid precipitations for that year have in all subsequent calculations been replaced by the average sub-basin values for 1987-1990.

### 2.3.2. Wind Fields in the Baltic Region

The winds over the Baltic are often quite variable but on an annual basis the area is dominated by west-southwesterly winds. This can be seen in *Figure 2.3.2.*, which shows the distribution of daily wind sectors at a number of measuring sites in the Baltic region.

The daily wind sectors are selected among the 8 sectors (45°) of the compass. The selection is based on 4 daily trajectories to the measurement sites calculated by MSC-W for the preceding 96 hours. If all trajectories have more than half of their route inside a sector over a distance from 1.500 km to 150 km from the site, that sector is allocated to that day at the station. If this criterion is not met no sector is allocated to the site for that day. The no-sector frequency is given in percentages at the center of the sector plots in *Figure 2.3.2.* This sector analysis is based on about 4750 trajectories to each site in the period 1978 to 1990.

**Figure 2.3.2.** Distribution of wind sectors at the stations: Rørvik, Kap Arkona, Hoburg, Utö, Ähtäri and Virolahti.



### 3. MONITORING NETWORK

The main purpose of the monitoring network is to produce data that can be used for estimating the deposition of harmful substances to the Baltic Sea. That purpose can only be fulfilled if data reported by the contracting parties are of a high quality. The monitoring stations shall be representative for the larger area and should not be significantly influenced by local pollution sources. The sampling and analytical methods shall be reliable and comparable.

#### 3.1. Stations

The EGAP Monitoring Network consists of 26 land-based measuring sites (see *Figure 2.1.1*). They are situated in various types of rural areas as listed in *Table 3.1.1*, so as to avoid the influence of local industrial sources. Measurements may nevertheless be influenced by local contributions and may, especially for ammonia, vary considerably depending on the surroundings of the sampling site.

The monitoring program is based on measurements of routine minimum requirement compounds, additional experimental measurements and a quality assurance procedure. These compounds and the corresponding data coverage are shown in *Table 3.1.2*. Further details are given in the Supplement to this report.

#### 3.2. Quality Assurance

The quality assurance protocol for monitored parameters used by the data host is similar to the EMEP Quality Assurance Plan (Schaug 1988). It is described in the Supplement to this report and can be summarized as follows.

**Statistical tests** are used to compare new measurements of gaseous, aerosol or precipitation compounds with previous data of each component already stored in the data base. The tests are carried out in order to identify possible outliers and erroneous results. They are based upon the assumption that the data possess a lognormal distribution and comprise comparisons with cumulative frequency distributions.

The data are split according to different seasons (i.e. winter and summer). Data outside three or four times the standard deviation have to be reconsidered by comparison with other components and concentrations at neighbouring stations.

In some cases the data deviate from a theoretical lognormal distribution, especially in the low concentration range where all concentrations below the detection limit are set equal to a small value. However, minor deviations from the theoretical function are acceptable.

**Ion Balance Computations** are also used as a tool. If all predominant species in precipitation are measured correctly the sum of positive and negative ionic concentrations should be balanced. Accordingly, the ratio between anion and cation concentrations should be close to one. The effect of minor constituents e.g. phosphates and organic acids, which are not included in the analysis is usually negligible in "acid precipitation". During sample storage soil dust, organic materials etc. might be dissolved, or biological processes might occasionally occur. Indications for these processes have to be suspected if deviations of the ionic sum from zero are found. In addition, precipitation samples sometimes seem to be supersaturated with carbon dioxide (compared to the concentration in air) and therefore contain more bicarbonate than expected. If a complete chemical analysis is performed the ionic balance test is useful for aerosol samples as well.

The ionic balance check should be carried out as soon as possible in order to be able to repeat the chemical analysis, if necessary.

In addition the **conductivity** of the precipitation samples is measured and compared with values calculated from the measured concentrations using equivalent ionic conductivities. Any data which appear uncertain should lead to a reinvestigation of the sample, if possible.

**Table 3.1.1. The HELCOM network stations**

Sub-basin	Station		Surrounding area
Gulf of Bothnia	Hailuoto <sup>a</sup>	(FI)	open sandy seashore
	Rahja	(FI)	forest land
	Rickleå	(SE)	
	Sulva	(FI)	agricultural land
	Ylimarkku	(FI)	agricultural and forest land
	Korppoo	(FI)	forest land
	Jomala	(FI)	agricultural land
Gulf of Finland	Virolahti <sup>b</sup>	(FI)	agricultural land
	Haapasaari	(FI)	rocky terrain, forest
	Vanhankylänmaa	(FI)	rocky terrain
	Sipoo	(FI)	agricultural land
	Lahemaa*	(SU)	forest land
	Tvärminne	(FI)	forest land
Baltic Proper, North	Utö*	(FI)	rocky terrain, island
	Aspvreten*	(SE)	forest land
	Syrve*	(SU)	land, sea
	Hoburg*	(SE)	cultivated land
	Rucava*	(SU)	cultivated land
Baltic Proper, South	Nida*	(SU)	sea, forest
	Arup	(SE)	forest land
	Leba	(PL)	meadow
	Kap Arkona*	(DD)	
Belt Sea and Kattegat	Rørvik*	(SE)	cultivated land, forest water
	Vavihill*	(SE)	forest area
	Keldsnor*	(DK)	cultivated land, beach
	Dän. Nienhof	(DE)	forest area

\* EMEP stations

a) data are from two different stations in this municipality: bulk monthly + wet monthly

b) data are from two different stations in this municipality: bulk monthly + bulk daily

**Table 3.1.2.** Development of the measuring activities 1986-1990

Constituents	No. of measuring stations				
	1986	1987	1988	1989	1990
<b>A. Nitrogen compounds, routine minimum requirements</b>					
NO <sub>3</sub> <sup>-</sup> precipitation	25	26	25	25	25
NH <sub>4</sub> <sup>+</sup> precipitation	25	26	25	25	25
<b>B. Nitrogen compounds in air, voluntary/experimental basis</b>					
NO <sub>2</sub> gas	9	8	12	10	9
HNO <sub>3</sub> - gas +	7	6	7	8	8
NO <sub>3</sub> <sup>-</sup> - particles					
NH <sub>3</sub> - gas +	8	6	7	8	8
NH <sub>4</sub> <sup>+</sup> - particles					
<b>C. Trace metals, voluntary/experimental basis *)</b>					
Pb precipitation	6	7	7	6	4
Cd precipitation	5	6	6	6	4
Zn precipitation	6	7	7	6	4
Cu precipitation	0	0	0	0	0
<b>D. Quality assurance</b>					
SO <sub>4</sub> <sup>2-</sup> precipitation	25	26	24	25	25
Na <sup>+</sup> precipitation	20	19	21	19	23
Mg <sup>2+</sup> precipitation	19	18	20	14	22
Cl <sup>-</sup> precipitation	19	19	18	20	21

\*) Routine minimum requirement from 1990

**3.3. Intercomparisons****3.3.1. Intercalibration Exercises**

In order to ensure the quality and comparability of the data collected EGAP has initiated and participated in a number of intercalibration and intercomparison exercises which have all been organized by Sweden. The first exercise was in its first stage concerned with the **analytical methods** used for the determination of trace metals, nitrate and ammonium in atmospheric precipitation (Ross, 1989). EGAP decided to emphasize the trace metal portions of this intercalibration because not all of the laboratories carry such analyses out routinely. The control of atmospheric trace metals has become essential because toxic metals such as Cd, As, Pb and Hg are known to contribute strongly to the pollution of the Baltic via atmospheric input. This first stage was carried out in 1986.

The outcome of the first stage justified the start of the second stage, an intercomparison of **procedures for precipitation sampling**, but for ammonium and nitrate only. It took place during 1987-1988. The results and conclusions from this first intercomparison are summarized below (HELCOM, 1991).

A comprehensive programme containing both intercalibration of analytical methods for trace metals in precipitation as well as an intercomparison of precipitation collectors was carried out in 1990. It was initiated by the Paris Commission (PARCOM) for the quality insurance within the *Comprehensive Atmospheric Monitoring Programme*. Following an invitation to all HELCOM countries many laboratories participated in the exercise. However, at the time being there is no report on results available.

**3.3.2. Results and Conclusions**

The **Ammonium and Nitrate Intercalibrations in 1986 and 1987-1988** showed that each of the 6 participating laboratories could accurately determine the contents of ammonium and nitrate in the 4 samples sent out. It was also concluded that systematic analytical errors could occur, but that they usually were smaller than the sampling errors arising from the use of different collectors.

The **intercomparison of precipitation sampling procedures in 1987-1988** showed that the main causes for mutual deviations were the different designs rather than the use of bulk or wet-only samplers or the length of the sampling periods. The maximum difference between different collectors were below 20 % for most components usually monitored at the stations.

With respect to estimation of depositions over the Baltic Sea it can be noted that this maximum difference in concentrations corresponds to a distance in Sweden of about 100 km. This is of no real significance since the difficulties in estimating the dry deposition at present contribute a much larger uncertainty.

The minimum participation for the **trace metal intercalibration** in 1986 required the analysis of Pb, Cu and Zn. Other metals determined on an optional basis were Cd, Fe and Mn. Various methods were used to test if the laboratories had control of contamination in the 6 samples that were sent out and the results from the 5 participating laboratories were found to contain a wide spread. It was concluded that for these components much additional work was needed. This could include a standardization of the analytical methods, as well as sample collection and handling procedures to reduce sample contamination inside the laboratory. These topics were discussed further at a special workshop on 'Collection and Analysis of Atmospheric Trace Metals' in Sweden in 1989 (National Swedish Environmental Protection Board, 1989).

The results from the trace metal intercomparison show that at present the trace metal concentrations in precipitation should be viewed with some caution. This is of course also valid for any derived estimates. For these reasons it has been decided to restrict the use of trace metal results in this report to lead.

#### 4 NUMERICAL MODELS

#### 4.1. Model Types

Recent studies have suggested, that North European marginal seas such as the North Sea and the Baltic are significantly affected by the atmospheric long range transport of man made emissions of pollutants. If control strategies for the reduction of the atmospheric deposition fluxes of pollutants to the Baltic Sea have to be developed, the only way of delineating the atmospheric transport pathways and hence the emitter-receptor relationship is through numerical modelling. However, due to the complexity of the physical and chemical processes to be treated in these models, a compromise between complexity and operational demands has to be found depending on the computer capacities, available input data and the spatial and temporal scales involved.

For long range transport of atmospheric pollutants and long term averages of concentration and deposition fields, **Lagrangian models** have proved to be an appropriate tool. In this type of models horizontal dispersion is represented by a large number of trajectories and a uniform vertical distribution is assumed in the atmospheric boundary layer. The mass balance for pollutants is calculated for air parcels following the motion along air pathway trajectories.

The model of MSC-W, as described by Eliassen and Saltbones (1983), was one of the first in this category to be developed for operational use (Iversen et al., 1989, 1990). It is a one-layer model where concentrations are calculated as averages over the well mixed layer and it is receptor oriented, since every six hours 4-day trajectories terminating at selected receptor points are calculated. After comprehensive tests and validations there are now 10 chemical components in the model [NO, NO<sub>2</sub>, PAN\*, HNO<sub>3</sub>, NO<sub>3</sub><sup>-</sup>, NH<sub>4</sub>NO<sub>3</sub>, NH<sub>3</sub>, SO<sub>2</sub>, SO<sub>4</sub><sup>2-</sup>, ((NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>+NH<sub>4</sub>HSO<sub>4</sub>)/2 = (NH<sub>4</sub>)<sub>1.5</sub>SO<sub>4</sub>].

The model is being used on a routine basis for the assessment of transboundary pollution fluxes and deposition of sulphur and nitrogen compounds over Europe. The results show that the concentration and deposition fields are predicted reasonably well. The model has in slightly modified form been used to calculate deposition of trace metals to the North Sea and the Baltic Sea, the difference being that no chemical or physical transformation is assumed for these pollutants (Petersen et al., 1989).

**Eulerian models** constitute another valuable model approach in which calculations are carried out in 3-dimensional grid points. The main advantages of complex Eulerian modelling are that complex atmospheric processes can be investigated in detail, that episodic events can be modelled, and that it is the appropriate frame for nesting mesoscale models required for evaluating specific environmental control measures.

Eulerian models, therefore, constitute a sophisticated supplement to the Lagrangian approach as research tools for improving the reliability of model calculations. With the rapid advances in computers and database management systems they are likely to be introduced over the next few years as routine tools for abatement strategies. As has been shown recently (EMEP-Workshop on Photo-Oxidant Modelling for Long-Range Transport in Relation to Abatement Strategies, Berlin, 16-19 April 1991) less sophisticated versions of Eulerian models already now constitute a practical and appropriate tool for such purposes.

The MSC-E has developed and tested a hybrid *Lagrangian-Eulerian* model for routine calculations of horizontal transport of air pollution. The application of the Eulerian scheme is useful for modelling the non-linearity of chemical processes, of washout, and of vertical wind variation.

#### 4.2. Model Inputs

Calculations of air quality and deposition of air pollutants require basic input information of two categories: meteorology and emissions.

The meteorological information needed differs a little between the two EMEP-models. The MSC-E model uses real meteorological observational data comprising the horizontal winds at the 850 and 1000 hPa levels, precipitation amounts, and surface temperature.

The main meteorological input data for the MSC-W model are the horizontal wind fields, precipitation and mixing height fields. The data are generated from objectively analyzed observations and from the Limited Area weather prediction Model of the Norwegian Meteorological Institute. The trajectories are calculated from the 925 hPa (~800 m altitude) windfield, which is considered to be representative for the horizontal advection in one-layer transport models.

Most of the meteorological data needed are taken from the Numerical Weather Prediction model (NWP). Through data assimilation in time and space meteorological observations are combined in an optimal way with short-term model predictions. The data assimilation cycle is 6 hours, and geopotential-height, horizontal wind, and relative humidity are analyzed from observations. Thus, observations are included in a way that does not counteract the physical laws of Nature. The NWP model carries prognostic equations for surface pressure, wind, temperature, water vapour, and liquid water, and a diagnostic equation (the hydrostatic equation) for the height of the coordinate surfaces. In the version employed in the EMEP-work, it is run with 150 km grid resolution with the EMEP-grid as a sub-grid. The model has 10 layers in the vertical, and includes a physical package with turbulent diffusion in the atmospheric boundary layer, stratiform and convective precipitation, and short- and long-wave radiation.

Precipitation is one of the key parameters for atmospheric deposition, since wet depositions due to in-cloud and below-cloud scavenging may account for more than 70% of the total annual deposition rates of some airborne pollutants in Europe. However, precipitation from single convective clouds as well as from large frontal systems is very intermittent and spatially varying when compared to the density in space and time of the synoptic rain collector network. Over continental regions six-hourly precipitation amounts are analyzed from observations. However, synoptic observations can be insufficient for a 6 h analysis in the model domain, especially for sea areas where almost no observations are available. Therefore precipitation fields over sea are derived from the NWP model.

The height of the atmospheric boundary layer defines the layer within which pollutants are dispersed and mostly scavenged. It is determined from radio soundings taken daily at 12<sup>00</sup> GMT, which in Europe approximates the afternoon maximum mixing height. Such soundings are however very sparse above the Baltic Sea. Joffre (1985) and Salmi & Joffre (1988) have shown that the marine atmospheric boundary layer height can vary significantly from 200 m in summer to 1500 m in early winter before sea freezing. The boundary layer heights over the Baltic used with the MSC-W model sometimes do not show this trend. Therefore this input parameter, like the precipitation fields over sea, is still an uncertain estimate, which should be the subject of further research.

The other set of essential input data for both EMEP models is the field of European emissions of both anthropogenic and natural pollutants. The assessment of emissions from anthropogenic sources and their spatial distribution in Europe is a key requirement for modelling the atmospheric input of nitrogen species and trace metals to the Baltic Sea. The major source of nitrogen oxides ( $\text{NO}_x = \text{NO} + \text{NO}_2$ ) is the high temperature combination of atmospheric nitrogen and oxygen in combustion processes in power plants and petrol-fuelled road vehicles. The budget calculations of nitrogen also require data on emissions of ammonia ( $\text{NH}_3$ ) for which the major source is agricultural activity. Trace

\*) PAN = Peroxy - Acetyl - Nitrate

metals are emitted into the atmosphere due to their volatility during high temperature process in power plants, smelters, mines, incinerators, steel and iron factories, and gasoline combustion.

Emission surveys for NO<sub>x</sub> and NH<sub>3</sub> (Iversen *et al.*, 1989, 1990) and for several trace metals (Pacyna, 1983) from various anthropogenic sources have been developed in the EMEP-grid system. The emissions of nitrogen oxides are taken from official national inventories submitted regularly within the EMEP cooperation and based on emission factors and statistical information. If not available the emission estimates of Semb and Amble (1981) are used. For ammonia official emission estimates are only available for one country. In all other cases the estimates of Buijsman *et al.* (1985, 1987) are used, but multiplied with a factor of 1.2 according to advice from these authors.

Thus, great efforts are spent on ensuring the quality and reliability of the emission data, since this is a prerequisite for reliable model results. Nevertheless, the emission data employed are of a varying quality and interpolations are often required to cover the whole grid net used in the model.

#### 4.3. Model Outputs

The EMEP models calculate daily concentrations and depositions. These values are averaged over one month and are classified in 36 emission and deposition domains that are listed in *Table 4.3.1*.

**Table 4.3.1.** Definition of codes for the sub-areas used in the emission-deposition matrices.

1	AL	Albania	19	PL	Poland
2	AT	Austria	20	PT	Portugal
3	BE	Belgium	21	RO	Romania
4	BG	Bulgaria	22	ES	Spain
5	CS	Czechoslovakia	23	SE	Sweden
6	DK	Denmark	24	CH	Switzerland
7	FI	Finland	25	TR	Turkey*
8	FR	France	26	SU	Soviet-Union*
9	DD	German Dem. Rep.	27	GB	United Kingdom
10	DE	Germany, Fed. Rep.	28	YU	Yugoslavia
11	GR	Greece	29	REM	Remaining areas*
12	HU	Hungary	30	BAS	The Baltic Sea
13	IS	Iceland	31	NOS	The North Sea
14	IE	Ireland	32	ATL	Rem. Atlantic Waters
15	IT	Italy	33	MED	The Mediterranean*
16	LU	Luxembourg	34	BLS	The Black Sea
17	NL	The Netherlands	35	NAT	Biogenic sea emissions
18	NO	Norway	36	IND	Dep. of indeterminate origins

\*) The part inside the EMEP domain of calculation.

Area 1 to 28 are European countries, area 29 is the part of North Africa that is included in the domain of calculation, area 30 to 34 are different European sea areas and area 35 represents deposition from biogenic sea emissions. Finally, area 36 represents depositions of indeterminate origin, a concept that is explained in more detail by Iversen *et al.*, (1990).

The governing differential equations in the models are all linear in the concentrations. Therefore, any two set of solutions to this system of equations can be added to give a sum that will also be a solution. This means that one can calculate the concentrations due to emissions in each sub-domain, and then sum over the individual contributions to get the total concentrations and depositions.

The model calculations lead to estimates of both dry and wet deposition D<sub>r</sub><sup>M</sup> as annual values in each of the 150 x 150 km<sup>2</sup> grid squares employed. The models contain algorithms that select a set of (fractional) grid squares as representing e.g. the Baltic Sea and the deposition to this area (No. 30) can therefore be calculated. The models are thus able to keep track of the domain in which the pollution was emitted which makes it possible to allocate the deposition on the whole Baltic Sea to relevant emitter countries.

The MSC-W-model uses the hybrid estimates P<sup>H</sup> for precipitation over the sea for this calculation but the model is not so detailed that a subdivision into the sub-basins applied in this report can be treated. However, the distribution of the deposition of nitrogen to different parts of the Baltic Sea can be seen in Appendix B which contains a number of plots that show the deposition in EMEP-grid squares. In contrast the MSC-E-model does allow total depositions on the sub-basins to be calculated but here the precipitation amounts are based on actual measurements.

## 5. MONITORING RESULTS

### 5.1. Air Concentrations

The measurement of ambient air concentrations of pollutants is not part of the minimum requirement programme of EGAP. Such data therefore constitute a voluntary contribution. These ambient air data are not in this report used for estimating the dry deposition since that can be handled more reliably by models which as the EMEP model have been verified experimentally.

The results presented below (*Tables 5.1.1-5.1.4*) for selected stations give an impression of the level and variation of ambient air concentrations. The parameters listed comprise gaseous NO<sub>2</sub> and the total (gaseous and particulate) phases of ammonium and nitrate defines as:

$$\text{NO}_2 = [\text{NO}_2 - \text{N}],$$

$$\text{Sum-NH}_x = [(\text{NH}_3 + \text{NH}_4^+)-\text{N}],$$

and

$$\text{Sum-NO}_y = [(\text{HNO}_3 + \text{NO}_3^-)-\text{N}].$$

**Table 5.1.1.** Seasonal mean values for air pollution concentrations in 1989 ( $\mu\text{g N/m}^3$ ).

Rörvik	NO <sub>2</sub>	Sum-NH <sub>x</sub>	Sum-NO <sub>y</sub>
Jan-Mar	2.93	1.50	0.73
Apr-Jun	1.43	1.34	0.58
Jul-Sep	1.37	0.99	0.47
Oct-Dec	3.13	1.06	0.65
YEAR	2.22	1.22	0.61

**Table 5.1.2.** Seasonal mean values for air pollution concentrations in 1989 ( $\mu\text{g N/m}^3$ ).

Aspvreten	NO <sub>2</sub>	Sum-NH <sub>x</sub>	Sum-NO <sub>y</sub>
Jan-Mar	2.47	1.06	0.62
Apr-Jun	0.85	0.95	0.53
Jul-Sep	0.93	0.86	0.38
Oct-Dec	1.98	0.71	0.40
YEAR	1.56	0.89	0.48

**Table 5.1.3.** Seasonal mean values for air pollution concentrations in 1989 ( $\mu\text{g N/m}^3$ ).

Utö	NO <sub>2</sub>	Sum-NH <sub>x</sub>	Sum-NO <sub>y</sub>
Jan-Mar	1.35		
Apr-Jun	1.57		
Jul-Sep	1.10	0.73	0.38
Oct-Dec	1.43	0.51	0.44
YEAR	1.36	0.62	0.41

**Table 5.1.4.** Seasonal mean values for air pollution concentrations in 1989 ( $\mu\text{g N/m}^3$ ).

Virolahti	NO <sub>2</sub>	Sum-NH <sub>x</sub>	Sum-NO <sub>y</sub>
Jan-Mar	2.03	1.08	0.65
Apr-Jun	1.80	1.49	0.44
Jul-Sep	1.13	0.89	0.27
Oct-Dec	2.20	0.82	0.38
YEAR	1.79	1.07	0.44

These results from a set of stations that roughly represent a west-east cross section of the central Baltic area show that the concentrations are at a minimum on both sides of the sub-basin A<sub>3</sub>, Proper North. For the oxidized components NO<sub>2</sub> and Sum-NO<sub>y</sub> there is a tendency for minimum values in the summer half of the year, particularly in the third quarter.

### 5.2. Precipitation Concentrations

The HELCOM/EGAP monitoring programme calls for determination of the concentrations of NH<sub>4</sub> and NO<sub>3</sub> and, from 1990, Pb, Cd, Cu, Zn as a minimum requirement [Chapter 3]. In this report the ammonium and nitrate results are used to calculate the concentration of total nitrogen, defined as

$$[\text{Tot-N}] = [\text{NH}_4\text{-N}] + [\text{NO}_3\text{-N}]$$

Such data are presented in *Table 5.2.1* below for Tot-N as annual averages at stations selected as representative of the various sub-basins as well as average values for the appropriate sub-basins. Similar data for the other pollutants can be found in Appendix C.1. Note that in all cases the units refer to the nitrogen content.

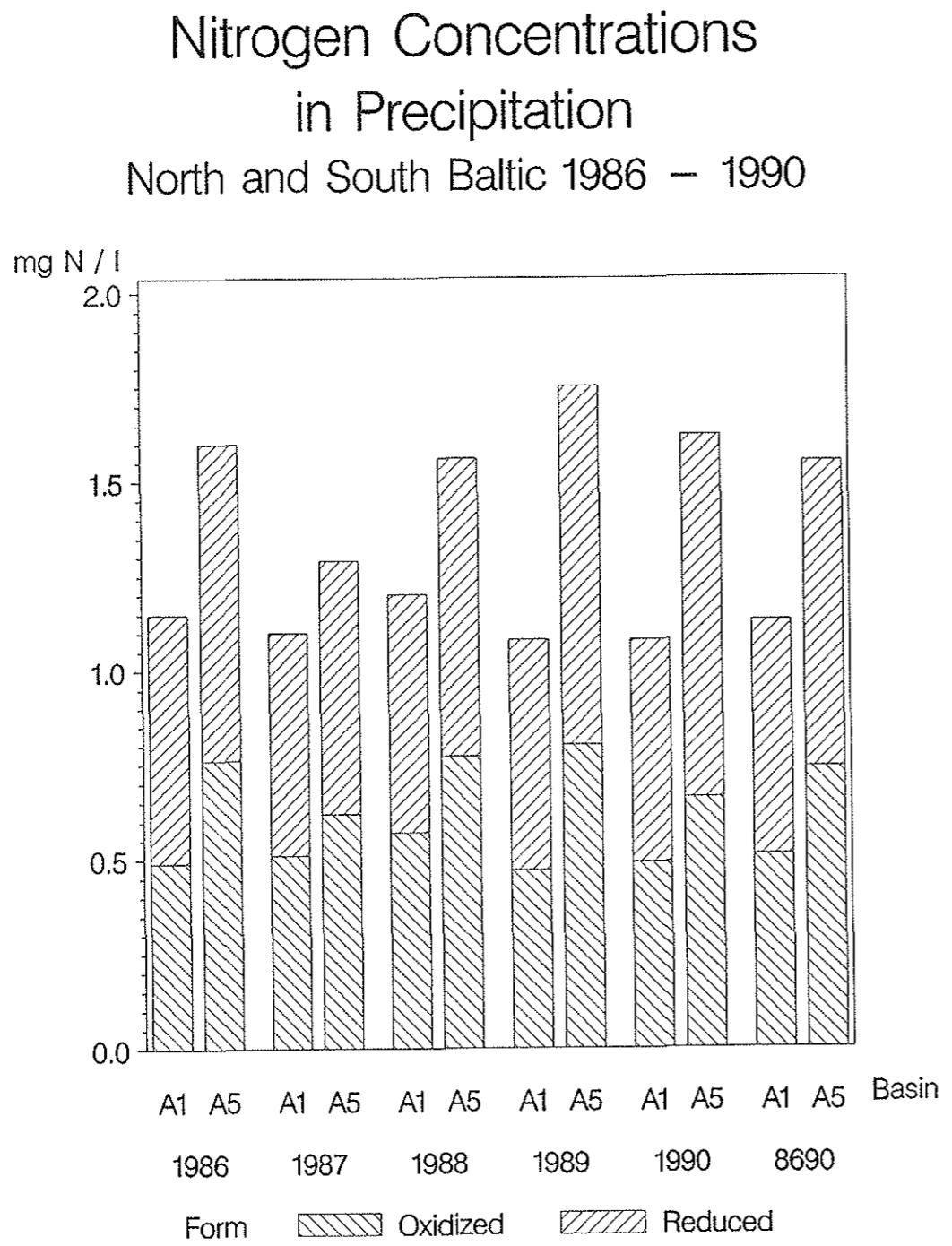
All values are precipitation weighted averages, including the basin averages

$$C_b = \sum C_s P_s / \sum P_s$$

where  $\Sigma$  ranges over the S<sub>b</sub> stations in the sub-basin b.

For all nitrogen compounds *Tables 5.2.2 - 5.2.4* summarize annual basin average concentrations as well as area-weighted overall averages for the whole Baltic Sea. The five-year average concentration of Tot-N in precipitation is seen to be 1.34 mg/l. There does not appear to be any temporal trend in the concentrations of the two types of nitrogen compounds. Geographically, however, there is a clear concentration gradient from north to south, presumably due to the varying distance to continental European sources. These features are also illustrated in *Figure 5.2.1* with annual concentration results from the most northern and southern sub-basins.

**Figure 5.2.1.** Annual average nitrogen concentrations in A<sub>1</sub>, Gulf of Bothnia, and in A<sub>5</sub>, Kattegat and Belt Sea.



**Table 5.2.1.** Annual mean concentrations of Tot-N in precipitation (mg N/l).

Gulf of Bothnia	1986	1987	1988	1989	1990	1986-90
Hailuoto	1.10	0.91	1.33	0.82	0.87	1.00
Rahja	0.86	0.55		0.53	0.52	0.62
Rickleå	0.69	0.84	0.84	0.88		0.81
Sulva	1.40	0.85	0.63	1.00	1.18	1.00
Ylimarkku	1.39	1.59	1.23	1.44	1.41	1.40
Korppoo	1.28	1.02	1.50	1.28	0.91	1.19
Jomala	1.25	1.83	1.48	1.46	1.22	1.41
Basin average:	1.15	1.10	1.19	1.07	1.08	1.12
Gulf of Finland	1986	1987	1988	1989	1990	1986-90
Virolahti	1.40	1.30	1.00	1.13	0.89	1.14
Haapasaari	1.40	1.05	1.23	1.77	1.70	1.38
Vanhankylämmaa	1.74	1.13	1.47			1.44
Sipo	1.36	1.13	1.22	1.00	0.79	1.10
Lahemaa	0.47	0.91	0.65	0.89	0.56	0.76
Tvärminne	1.23	1.35	1.32	1.42	0.99	1.24
Basin average:	1.42	1.17	1.16	1.18	0.94	1.17
Baltic Proper, North	1986	1987	1988	1989	1990	1986-90
Utö	1.90	1.09	1.57	1.53	1.32	1.49
Aspvreten	0.92	0.76	1.01	1.23		0.96
Syrve	0.91	1.20	1.16	1.45	1.22	1.19
Hoburg	1.66	1.52	2.34	2.32	2.61	2.12
Rucava	1.23	0.90	0.82	1.26	0.98	1.04
Basin average:	1.30	1.06	1.27	1.50	1.41	1.32
Baltic Proper, South	1986	1987	1988	1989	1990	1986-90
Nida	1.24	1.53	2.05		1.38	1.45
Arup	1.38	1.03	1.31	1.65		1.33
Leba		1.63	1.20	1.23	1.06	1.27
Kap Arkona	1.72	2.63	1.80	1.66	1.52	1.87
Basin average:	1.47	1.68	1.45	1.52	1.30	1.47
Belt Sea and Kattegat	1986	1987	1988	1989	1990	1986-90
Rörvik	1.67	1.21	1.51	1.47	1.27	1.42
Vavihill	1.55	1.15	1.30	1.97	1.87	1.55
Keldsnor	1.59	1.88	1.82	1.56	1.81	1.74
Kiel Bight	3.18					3.18
Dänisch-Nienhof		1.22	1.75	1.87		1.35
Basin average:	1.60	1.29	1.56	1.75	1.62	1.56

**Table 5.2.2.** Annual mean sub-basin concentrations of Tot-N in precipitation (mg N/l).

Sub-basin	1986	1987	1988	1989	1990	1986-90
A <sub>1</sub> Gulf of Bothnia	1.15	1.10	1.19	1.07	1.08	1.12
A <sub>2</sub> Gulf of Finland	1.42	1.17	1.16	1.18	0.94	1.17
A <sub>3</sub> Baltic Proper, North	1.30	1.06	1.27	1.50	1.41	1.32
A <sub>4</sub> Baltic Proper, South	1.47	1.68	1.45	1.52	1.30	1.47
A <sub>5</sub> Belt Sea and Kattegat	1.60	1.29	1.56	1.75	1.62	1.56
A <sub>0</sub> Baltic Sea Average	1.38	1.26	1.34	1.40	1.29	1.34

**Table 5.2.3.** Annual mean sub-basin concentrations of NO<sub>3</sub> in precipitation (mg N/l).

Sub-basin	1986	1987	1988	1989	1990	1986-90
A <sub>1</sub> Gulf of Bothnia	0.49	0.51	0.57	0.47	0.49	0.51
A <sub>2</sub> Gulf of Finland	0.67	0.50	0.60	0.53	0.49	0.57
A <sub>3</sub> Baltic Proper, North	0.73	0.57	0.64	0.76	0.70	0.67
A <sub>4</sub> Baltic Proper, South	0.72	0.92	0.73	0.68	0.62	0.76
A <sub>5</sub> Belt Sea and Kattegat	0.76	0.62	0.77	0.80	0.66	0.74
A <sub>0</sub> Baltic Sea Average	0.67	0.62	0.67	0.65	0.60	0.64

**Table 5.2.4.** Annual mean sub-basin concentrations of NH<sub>4</sub> in precipitation (mg N/l).

Sub-basin	1986	1987	1988	1989	1990	1986-90
A <sub>1</sub> Gulf of Bothnia	0.66	0.59	0.63	0.61	0.59	0.62
A <sub>2</sub> Gulf of Finland	0.74	0.67	0.56	0.65	0.45	0.66
A <sub>3</sub> Baltic Proper, North	0.57	0.49	0.64	0.74	0.71	0.61
A <sub>4</sub> Baltic Proper, South	0.75	0.76	0.72	0.83	0.68	0.77
A <sub>5</sub> Belt Sea and Kattegat	0.84	0.67	0.79	0.95	0.96	0.81
A <sub>0</sub> Baltic Sea Average	0.71	0.64	0.68	0.76	0.69	0.70

Measurement of lead and other metals in precipitation are not available from all stations and as results on Cd and Zn are not considered sufficiently reliable (cf. Chapter 3) data are given for lead only and in slightly different form in Table 5.2.5. All values are precipitation weighted averages.

**Table 5.2.5.** Annual mean concentration of lead in precipitation ( $\mu\text{g/l}$ ).

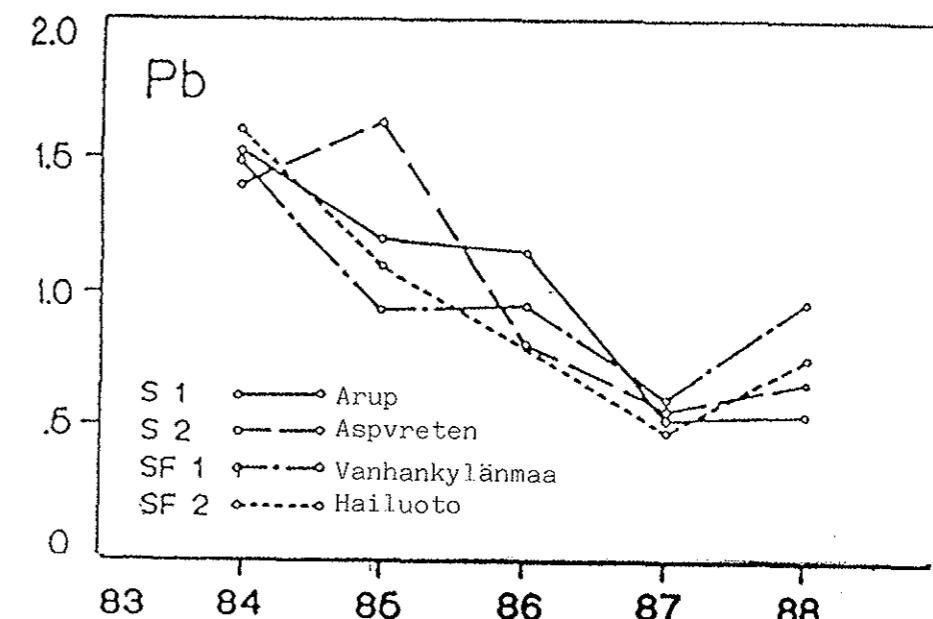
	1986	1987	1988	1989	1990	1986-90
Hailuoto	2.59	1.96	2.93	5.23	15.63	5.20
Haapasaari	5.32	4.50	4.73	22.50	9.94	8.58
Vanhankylänmaa	5.44	2.94	5.48			4.59
Aspvreten	4.46	2.98	3.69	4.24		3.84
Arup	7.51	2.96	3.44	3.38		3.26
Leba			13.13	14.34	7.17	11.14
Dänisch-Nienhof	5.55*	4.90	4.10	3.99**	4.90	
Baltic Sea Average	5.22	3.57	4.79	9.10	6.86	5.84

\* only May to December

\*\* only January and February

The results contain some very large concentrations that confirm the suspicions regarding the quality of this type of data. These atypical results mask any temporal or geographical tendency that otherwise might have been apparent.

Apparent trends of annual mean concentrations of lead at two Swedish and Finnish stations are shown in Figure 5.2.2 for the years 1984-1988. However, the downward trend is broken in 1988 and the data in Table 5.2.5 indicate a rise into 1989 and 1990. Thus, neither the data, nor their quality allow any definite conclusions on trends to be drawn.

**Figure 5.2.2.** Relative annual mean concentrations of lead in bulk deposition during 1984-1988. Results are normalized to the 5-year mean at the corresponding station.

## 6. NITROGEN DEPOSITION

### 6.1. Estimates for Wet Deposition Fluxes

The wet deposition is estimated on the basis of the precipitation weighted mean concentrations  $c_s$  measured at the stations s and shown in *Table 5.2.1* and in Appendix C. To calculate the sub-basin depositions the first step is to obtain the annual deposition flux, i.e. the area specific deposition. Here two different methods are used.

#### 6.1.1. Experimental Deposition Fluxes

The first method relies exclusively on measurement data on concentrations  $c_s$  and the precipitation recorded at the various coastal stations  $P_s^X$ . The method presupposes that this precipitation is representative also for the open sea. That is a crude approximation as explained earlier when these precipitation data were used to calculate the sub-basin precipitations  $P_b^X$  in *Table 2.3.1*.

For each station s the annual deposition flux, i.e. the area specific annual deposition  $F_{ws}^X$ , is calculated as

$$F_{ws}^X = c_s \cdot P_s^X \text{ (mass/area/year)},$$

where superscript X refers to the experimentally based estimation. This is used for calculation of the annual deposition flux for each sub-basin b

$$F_{wb}^X = \sum F_{ws}^X / S_b,$$

where the sum is over the number of stations  $S_b$  in the basin. Thus another approximation is introduced since all stations in a sub-basin are given equal weight irrespective of the precipitation amount or the area represented by the station. Weighing by precipitation does, however, imply the use of squared precipitations which does not go well with the precipitation weighted concentrations. Area weighing is also problematic because of the difficulties of assigning areas to stations in a geographically uneven network.

The data on  $F_w^X$  are given for total nitrogen in *Table 6.1.1* and for other pollutants in Appendix C.2. The average sub-basin fluxes  $F_{wb}^X$  in 1986-1990 as well as the area weighted flux to the whole Baltic Sea are summarized in *Table 6.1.2* for all three nitrogen compounds.

**Table 6.1.1.** Wet deposition fluxes  $F_w^X$  of Tot-N, (kg-N/(km<sup>2</sup> yr)).

Gulf of Bothnia	1986	1987	1988	1989	1990	1986-90
Hailuoto	542	475	569	415	329	466
Rahja	423	256		290	168	284
Rickleå	403	349	368	468	339	385
Sulva	752	446	381	492	659	546
Ylimarkku	857	792	798	842	789	816
Korppoo	987	768	1019	681	683	828
Jomala	913	1000	1027	895	1144	996
Basin average:	697	584	694	583	587	629
Gulf of Finland	1986	1987	1988	1989	1990	1986-90
Virolahti	925	842	724	803	615	782
Haapasaari	616	620	506	628	603	594
Vanhankylänmaa	990	666	814			823
Sipoo	1054	661	780	672	598	753
Lahemaa		371	273	546	262	363
Tvärminne	813	985	797	787	863	849
Basin average:	880	691	649	687	588	699
Baltic Proper, North	1986	1987	1988	1989	1990	1986-90
Utö	1122	519	790	814	819	813
Aspvreten	563	391	599	469	412	487
Syrve	487	581	895		1150	778
Hoburg	720	565	964	819	1374	888
Rucava	1045	586	624		905	790
Basin average:	787	529	774	701	932	745
Baltic Proper, South	1986	1987	1988	1989	1990	1986-90
Nida	394	369	349		1029	535
Arup	960	713	1297	965	1139	1015
Leba		1028	771	630	777	802
Kap Arkona	955	1446	989	822	819	1006
Basin average:	770	889	852	806	941	852
Belt Sea and Kattegat	1986	1987	1988	1989	1990	1986-90
Rörvik	1104	889	1258	868	1083	1040
Vavihill	1154	985	1187	1508	1546	1276
Keldsnor	709	723	922	620	938	783
Kiel Bight	1202					1202
Dänisch-Nienhof		872	1440	1017		1110
Basin average:	1042	867	1202	1003	1189	1061

**Table 6.1.2.** Average experimental sub-basin fluxes  $F_{wb}^x$  for the years 1986-1990 (kg N/(km<sup>2</sup>yr)).

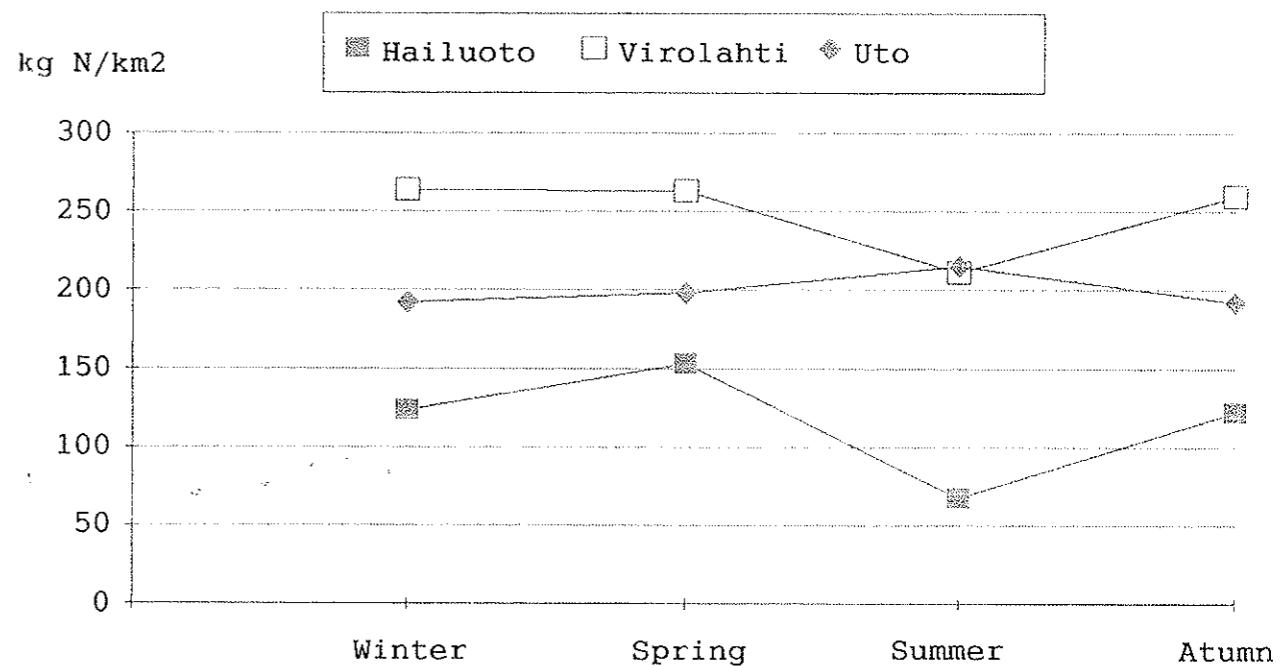
Sub-basin	Tot-N	NO <sub>3</sub>	NH <sub>4</sub>
A <sub>1</sub> Gulf of Bothnia	629	284	345
A <sub>2</sub> Gulf of Finland	699	322	357
A <sub>3</sub> Baltic Proper, North	745	384	361
A <sub>4</sub> Baltic Proper, South	852	419	432
A <sub>5</sub> Belt Sea and Kattegat	1061	489	571
A <sub>0</sub> Baltic Sea Average	797	380	413

It can be seen that there is a clear and consistent tendency for larger fluxes in the more southern parts of the Baltic Sea which are closer to the European air pollution sources.

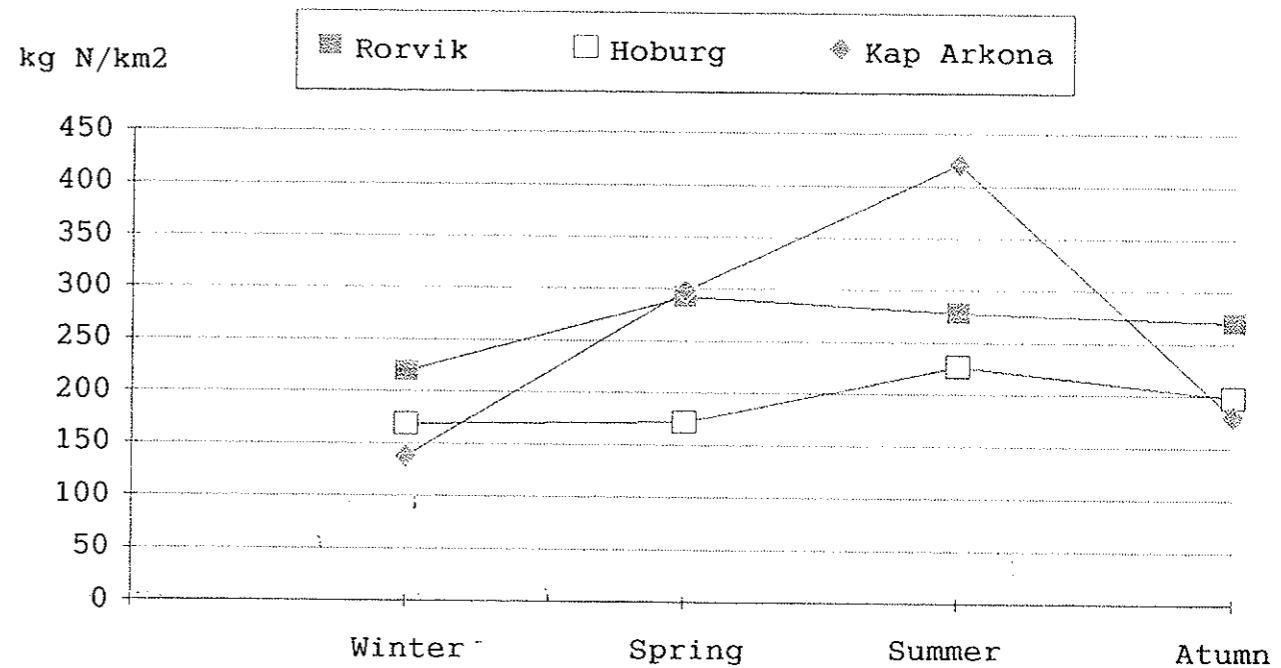
The average seasonal variations of the wet deposition fluxes  $F_w^x$  for total nitrogen in 1986-1989 are shown in Figures 6.1.1.- 6.1.2. at stations selected in the various sub-basins. The values shown are 3 month averages which represent the seasons (quarters) of the year.

There does not seem to be any common variation over the year and geographically the curves appear to differ only with respect to the annual mean level.

**Figure 6.1.1.** Average seasonal variations of wet deposition fluxes  $F_w^x$  for Tot-N at some northern stations (1986-1989). Units: kg N/km<sup>2</sup>.



**Figure 6.1.2.** Average seasonal variations of wet deposition fluxes  $F_w^x$  for Tot-N at some southern stations (1986-1989). Units: kg N/km<sup>2</sup>.



### 6.1.2. Hybrid Deposition Fluxes

The second estimation method relies on both measurement data and model calculations. As noted earlier the hybrid estimates of precipitation over the sea are considered more reliable than extrapolation of coastal measurements. These estimates of annual precipitation fluxes are given for all sub-basins in *Table 2.3.2.* With the basin average concentrations in *Table 5.2.2. - 5.2.4* denoted by  $c_b$  the hybrid estimate of the basin flux is

$$F_{wb}^H = c_b \cdot P_b^H$$

The 5-year average fluxes are shown in *Table 6.1.3.* for Tot-N, NO<sub>3</sub>, and NH<sub>4</sub> as well as the ratios of hybrid to experimental fluxes.

*Table 6.1.3. Average hybrid sub-basin fluxes  $F_{wb}^H$  for the years 1986\*-1990 (kg N/(km<sup>2</sup> yr)).*

Sub-basin	Tot-N	NO <sub>3</sub>	NH <sub>4</sub>	$F_w^H / F_w^X$
A <sub>1</sub> Gulf of Bothnia	703	318	385	1.12
A <sub>2</sub> Gulf of Finland	854	406	448	1.22
A <sub>3</sub> Baltic Proper, North	676	351	325	0.91
A <sub>4</sub> Baltic Proper, South	1007	496	511	1.18
A <sub>5</sub> Belt Sea and Kattegat	1164	536	628	1.10
A <sub>0</sub> Baltic Sea Average	881	421	459	1.11

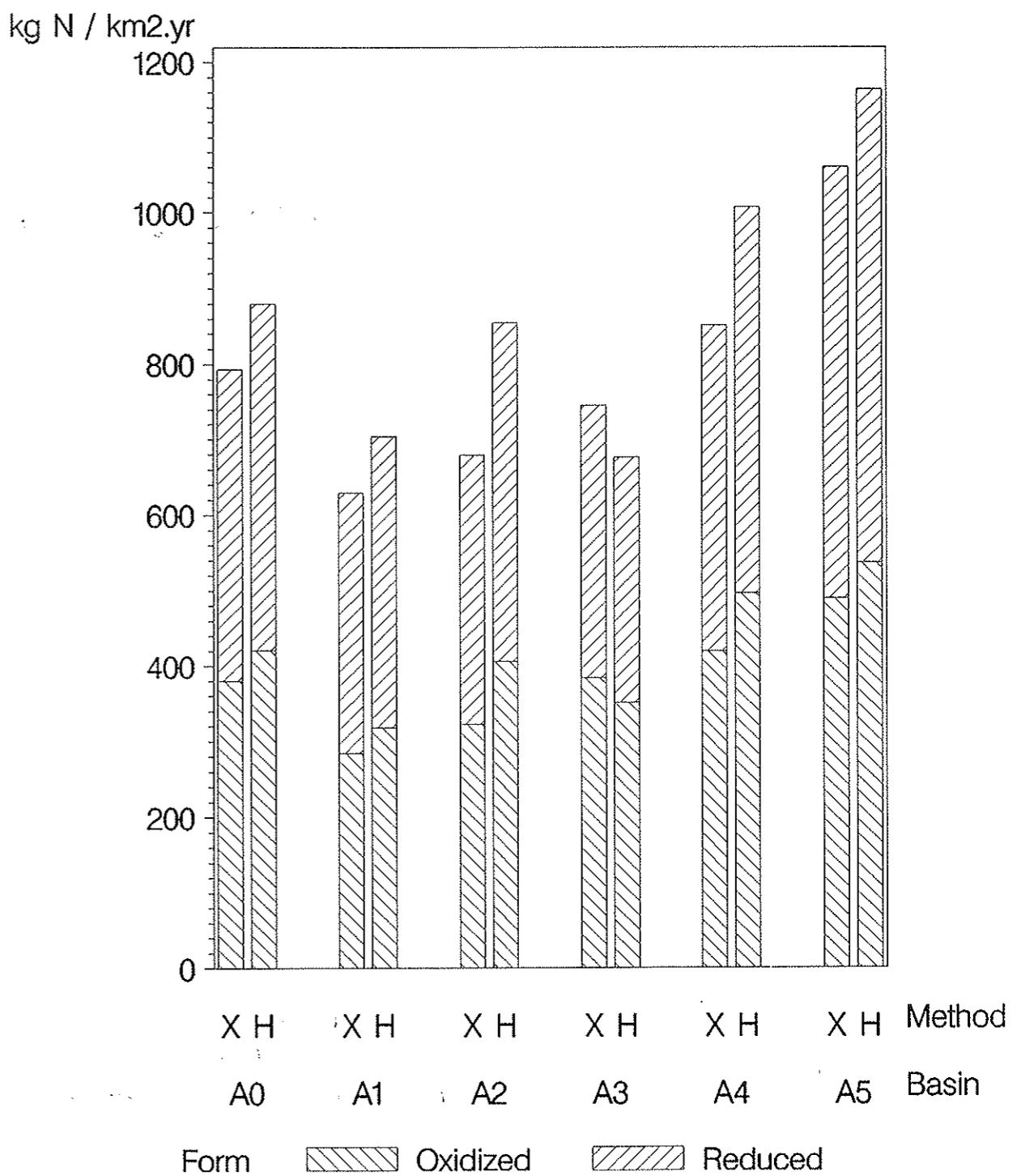
\*) For 1986 the average values of  $P^H$  for 1987-1990 have been used.

These fluxes exhibit the same north-south gradient as do the experimental fluxes in *Table 6.1.2.* The hybrid fluxes are, however, larger than the experimental ones, except for sub-basin A<sub>3</sub>. The ratios ( $F_w^H / F_w^X$ ) are essentially the same for all the nitrogen compounds but they vary geographically with an overall value for the Baltic Sea as a whole of about 1.1 and with a minimum in the central sub-basin, the Baltic Proper, North. These ratios are the same as the corresponding precipitation ratios ( $P^H / P^X$ ) in *Table 2.3.2.* and the flux differences can therefore be ascribed mainly to the differences in the precipitation estimates.

The two sets of fluxes are also shown in *Figure 6.1.3* from which it is evident that the gradient is more pronounced for reduced than for oxidized nitrogen.

*Figure 6.1.3. Average wet fluxes of nitrogen to the Baltic sub-basins for 1986-1990.*

## Wet Fluxes to the Baltic Nitrogen 1986 – 1990



## 6.2. Experimental Estimates of Wet Deposition

On the basis of the deposition fluxes the wet deposition to the basins can now be estimated by the two methods.

$$D_{wb}^x = A_b \cdot F_{wb}^x$$

and

$$D_{wb}^H = A_b \cdot c_b \cdot P_b^H = A_b \cdot F_{wb}^H$$

Here the experimental deposition  $D_{wb}^x$  is based on extrapolation of measurements of both concentrations and precipitation at the EGAP stations. The hybrid deposition  $D_{wb}^H$  is based on concentration measurements at the EGAP stations and on NWP model calculations for precipitation over the sea. The wet depositions for Tot-N are shown for all years and all basins in Tables 6.2.1 - 6.2.2. Similar results for the depositions of nitrate and ammonium are shown in Appendix C.3.

**Table 6.2.1.** Annual wet sub-basin depositions  $D_{wb}^x$  of Tot-N (kT N/yr).

Sub-basin	1986	1987	1988	1989	1990	1986-90
A <sub>1</sub> Gulf of Bothnia	80	67	80	67	68	73
A <sub>2</sub> Gulf of Finland	26	20	19	20	17	21
A <sub>3</sub> Baltic Proper, North	131	88	129	117	155	124
A <sub>4</sub> Baltic Proper, South	47	54	52	49	57	52
A <sub>5</sub> Belt Sea and Kattegat	44	37	51	43	50	45
A <sub>0</sub> Baltic Sea Total	329	267	331	296	349	314

**Table 6.2.2.** Annual wet sub-basin depositions  $D_{wb}^H$  of Tot-N (kT N/yr).

Sub-basin	1986*	1987	1988	1989	1990	1986*-90
A <sub>1</sub> Gulf of Bothnia	85	77	86	78	80	81
A <sub>2</sub> Gulf of Finland	30	24	24	26	22	25
A <sub>3</sub> Baltic Proper, North	114	88	119	114	127	112
A <sub>4</sub> Baltic Proper, South	61	70	59	58	61	62
A <sub>5</sub> Belt Sea and Kattegat	51	38	50	49	60	50
A <sub>0</sub> Baltic Sea Total	340	297	338	325	349	330

\*) For 1986 the average values of  $P^H$  for 1987-1990 have been used.

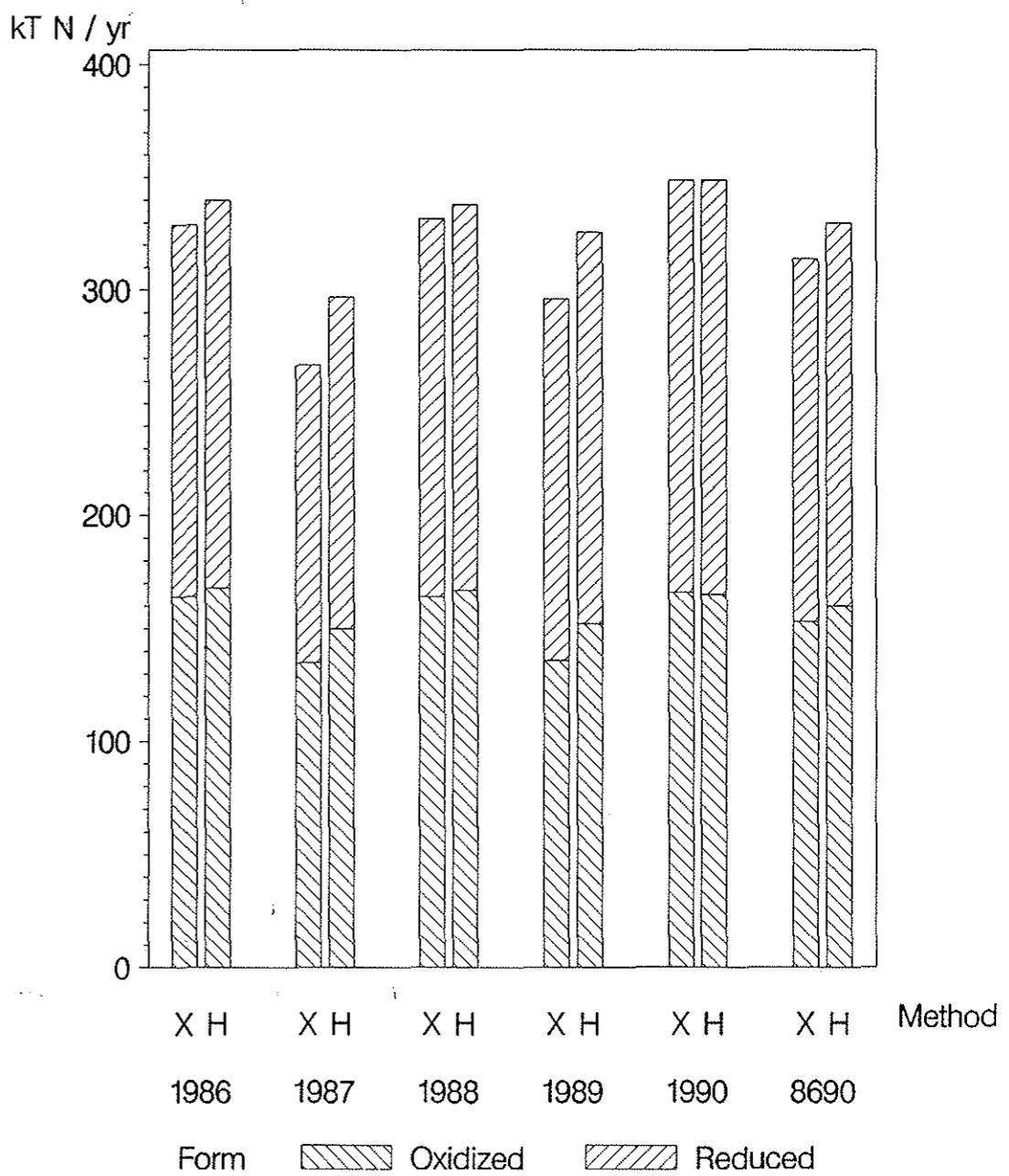
The values for deposition in 1986 compare quite well with the estimates published earlier (HELCOM 1989, Part II, Tables 4 and 5) but the present estimates are lower in the north with about 20% but higher in the two southern basins with about 10 %. For the total Baltic Sea area the present value of  $D_{wb}^x$  is almost equal to the previous one of 326 kT N.

The total annual depositions to the Baltic Sea, split into oxidized and reduced nitrogen (Appendix C.3), are shown in Figure 6.2.1. These results show that the nitrogen deposition to the Baltic Sea is divided almost equally between oxidized and reduced compounds. There is no discernible temporal trend during the latter half of the 1980s.

The average sub-basin depositions in 1986-1990 as well as the area weighted deposition to the whole Baltic Sea are summarized in Tables 6.2.3-6.2.4 for all three nitrogen compounds.

**Figure 6.2.1.** Estimates for annual wet deposition of nitrogen to the Baltic Sea 1986-1990.

## Wet Depositions to the Baltic Nitrogen 1986 – 1990



**Table 6.2.3.** Average experimental wet depositions  $D_{wb}^x$  for the years 1986-1990 (kT N/yr).

Sub-basin	Tot-N	$\text{NO}_3$	$\text{NH}_4$
A <sub>1</sub> Gulf of Bothnia	73	33	40
A <sub>2</sub> Gulf of Finland	21	9	11
A <sub>3</sub> Baltic Proper, North	124	64	60
A <sub>4</sub> Baltic Proper, South	52	26	26
A <sub>5</sub> Belt Sea and Kattegat	45	21	24
A <sub>0</sub> Baltic Sea Total	314	153	161

**Table 6.2.4.** Average hybrid wet depositions  $D_{wb}^H$  for the years 1986\*-1990 (kT N/yr).

Sub-basin	Tot-N	$\text{NO}_3$	$\text{NH}_4$	$D_w^H / D_w^x$
A <sub>1</sub> Gulf of Bothnia	81	37	44	1.11
A <sub>2</sub> Gulf of Finland	25	12	13	1.22
A <sub>3</sub> Baltic Proper, North	112	58	54	0.90
A <sub>4</sub> Baltic Proper, South	62	30	31	1.19
A <sub>5</sub> Belt Sea and Kattegat	50	23	27	1.10
A <sub>0</sub> Baltic Sea Total	330	160	170	1.05

\*) For 1986 the average values of  $P^H$  for 1987-1990 have been used.

The average ratio of hybrid to experimental estimates of the deposition is included in *Table 6.2.4*. As was the case for the precipitation and the fluxes the hybrid method leads to estimates which are larger by about 10 % than the purely experimental method and the deposition ratios have a similar geographical variation.

As already noted this is probably an effect of the dependence of the calculations on the siting of the measurement stations. That this dependence is actually quite critical is emphasized by the tendency of the hybrid method to yield less precipitation over sea than over land.

### 6.3. Dry Deposition

The dry deposition of gaseous and particulate nitrogen compounds to the Baltic Sea is not expected to be very significant partly due to their relatively low air concentrations in this area and partly due to their low dry deposition velocities.

On the basis of measurements from selected stations in the Baltic area Lindfors et al., (1991) have obtained the estimates for deposition rates for inorganic nitrogen shown in *Table 6.3.1*. The dry deposition is dominated by the gaseous components and it is divided almost equally between oxidized and reduced nitrogen compounds. The uncertainty involved is judged to be less than 50 %. It is seen that the dry contribution to the nitrogen deposition is less than 25 % in the southern sea areas and of the order of 10 % in the central and northern parts of the Baltic Sea, resulting in an overall dry contribution of about 15 %. The wet deposition estimated for the whole Baltic Sea is about 10 % larger than the wet depositions in *Tables 6.2.1.* and *6.2.2.*

**Table 6.3.1.** Experimental estimates for deposition rates to the Baltic Sea 1980-1986 (kg N/km<sup>2</sup> yr)). (From Lindfors et al., 1991).

	Area km <sup>2</sup>	Dry (gas & aerosol)	Wet	Total
A. Northern Baltic	185 000	84	650	734
B. Central Baltic	128 000	84	910	994
C. Southern Baltic	102 000	349	1140	1489
Baltic Sea Total	415 000	149	850	1000
Deposition, kT / yr		62	353	415

#### 6.4. Model Estimates for Total Deposition

With the EMEP-models it is as explained earlier possible to calculate the total dry and wet deposition to the Baltic Sea and to allocate this deposition to the various emitter countries given in *Table 4.3.1.*

The source split deposition estimates  $D_T^{M-W}$  calculated by the MSC-W-model are given for the nitrogen compounds in *Table 6.4.1.* It should be noted, however, that only very few countries have supplied official emission data for ammonia. In all other cases unofficial estimates from 1985 have been used. In addition, results for 1990 must be considered as preliminary in accordance with the reporting routine of annual emissions from the participating countries (Iversen et al., 1990).

Similar deposition estimates  $D_T^{M-E}$  calculated by MSC-E are shown in *Table 6.4.2.* but for oxidized nitrogen only. The agreement for this component is quite good among the two sets of results.

**Table 6.4.1.** Total (wet and dry) deposition  $D_T^{M-W}$  of nitrogen-compounds to the Baltic Sea (kT N/yr).

Model results from MSC-W (Iversen et al. 1990).

HELCOM member countries are marked with an asterisk (\*).

DD<sup>\*1)</sup> Not Contracting Party after the German unification by 3 October 1990.

	1988			1989			1990		
	Red.N	Ox.N	Tot-N	Red.N	Ox.N	Tot-N	Red.N	Ox.N	Tot-N
BE	1.1	2.9	4.0	1.2	2.9	4.1	1.3	3.4	4.7
CS	2.0	6.6	8.6	1.7	5.9	7.6	1.1	4.5	5.6
DK*	13.1	7.5	20.1	14.1	8.6	22.7	14.9	8.9	23.8
FI*	2.7	5.8	8.5	2.2	4.8	7.0	2.6	5.7	8.3
FR	3.3	6.9	10.2	3.2	7.5	10.7	4.0	8.4	12.4
DD <sup>*1)</sup>	9.6	14.3	23.9	9.2	13.8	23.0	9.4	13.3	22.7
DE*	9.5	33.2	42.7	8.6	30.6	39.2	10.1	34.7	44.8
NL	5.1	6.8	11.9	4.7	6.7	11.4	6.0	8.4	14.4
NO	0.6	1.8	2.4	0.7	2.2	2.9	0.7	2.2	2.9
PL*	15.5	18.8	34.3	13.8	15.6	29.4	11.0	12.7	23.7
SE*	6.1	10.4	16.5	6.5	11.2	17.7	6.4	11.5	17.9
SU*	25.7	12.8	38.5	16.9	6.7	23.6	16.2	8.3	24.5
GB	3.8	17.1	20.9	3.7	17.6	21.3	5.3	25.0	30.3
BAS	0.0	2.7	2.7	0.0	2.7	2.7	0.0	2.8	2.8
NOS	0.0	2.2	2.2	0.0	2.3	2.3	0.0	2.7	2.7
XEUR	3.1	4.3	7.5	3.0	4.1	7.1	2.3	4.4	6.7
IND	14.8	15.2	30.0	14.4	14.3	28.7	15.8	16.3	32.1
SUM	116.1	169.3	285.4	103.7	157.5	261.2	107.1	173.2	280.3

XEUR: Minor contributors < 1000 tonnes.

**Table 6.4.2.** Total (wet and dry) deposition  $D_T^{M-E}$  of oxidized nitrogen to the Baltic Sea (kT N/yr).

Model results from MSC-E.  
HELCOM member countries are marked with an asterisk (\*).  
+) Including contributions from Ukraine and Byelorussia.

	1988	1989
BE	2.7	2.3
CS	8.0	6.7
DK*	7.3	6.5
FI*	5.4	4.1
FR	7.9	8.2
DD*	9.7	8.8
DE*	33.9	28.9
NL	6.3	5.6
NO	3.2	3.3
PL*	16.4	13.0
SE*	11.9	10.9
SU*	8.0 +	5.1
GB	21.9	24.3
BAS	2.1	1.7
NOS	1.1	1.2
XEUR	10.3	4.5
IND	7.0	6.9
SUM	163.1	146.6

XEUR: Minor contributors < 1000 tonnes.

The model calculations show that the main contribution of about 60 % comes from the Baltic Sea Countries, probably because of their proximity. Other prominent contributors are Great Britain, France and the Netherlands, which are all upwind of the predominant westerly winds in the Baltic and which are also among the major European emitters. Czechoslovakia is another major contributor.

The depositions to the various sub-basins of the Baltic Sea have been estimated by MSC-E but for oxidized nitrogen only. The results are given in *Table 6.4.3.*

The variations among the annual depositions may be a consequence both of varying emissions and of interannual meteorological variability.

**Table 6.4.3.** Total (wet and dry) deposition  $D_T^{M-E}$  of oxidized nitrogen to the sub-basins of the Baltic Sea (kT N/yr).  
Model results from MSC-E.

Sub-basin	1988	1989
A <sub>1</sub> Gulf of Bothnia	28.0	23.7
A <sub>2</sub> Gulf of Finland	13.0	13.6
A <sub>3</sub> Baltic Proper, North	55.5	49.9
A <sub>4</sub> Baltic Proper, South	45.8	40.2
A <sub>5</sub> Belt Sea and Kattegat	20.8	19.2
A <sub>0</sub> Baltic Sea Total	163.1	146.6

### 6.5. Assessment of the Nitrogen Deposition

The wet deposition estimates  $D_w^X$  and  $D_w^H$  and the total dry and wet deposition  $D_T^M$  of nitrogen compounds to the Baltic Sea area in 1988-1990 are summarized in *Table 6.5.1*. The dry depositions have been taken from the experimental values of FMI given in *Table 6.3.1*.

**Table 6.5.1.** Annual depositions of nitrogen to the Baltic Sea (kT N/yr).

Depos.type	1988			1989			1990		
	Red.N	Ox.N	Tot-N	Red.N	Ox.N	Tot-N	Red.N	Ox.N	Tot-N
Dry: $D_d^X$ *)			60			60			60
Wet: $D_w^X$	168	164	331	160	136	296	183	166	349
Wet: $D_w^H$	171	167	338	174	152	325	184	165	349
Total: $D_T^{M-W}$	116	169	285	104	158	261	107	173	280
Total: $D_T^{M-E}$		163			147				

\*) Valid for 1980-1986

It is remarkable that the wet depositions of nitrogen estimated by both the experimental and the hybrid methods are larger than the total dry and wet deposition calculated by the EMEP-models. This discrepancy is enhanced if the experimental dry depositions are also included. A previous version of the MSC-W-model (Iversen et al., 1989) gave the somewhat higher estimate of 315 kT N for total nitrogen deposition in 1988.

The discrepancy may be a direct effect of the use of coastal concentration data for estimating wet depositions over the sea. This method which is used in both types of wet deposition estimates may actually yield overestimations because no account is taken of precipitation scavenging prior to the actual deposition.

A closer look at *Table 6.5.1* shows that the main discrepancy between model results and the deposition estimates based on extrapolation of measurements is found for the depositions of reduced nitrogen. For this component the model results  $D_T^{M-W}$  are only 60 % of the  $D_w^X$  and  $D_w^H$  estimates. For oxidized nitrogen, on the other hand the three types of estimates agree quite well within about 5 % although  $D_T^M$  also includes the dry deposition.

For ammonia, NH<sub>3</sub>, it should be recalled that most measurements are placed in rural surroundings to minimize the influence from local industrial activity. The sources of ammonia are, however, predominantly ground-level agricultural areas and the sites may therefore often be located in surroundings with significant emissions. The measurements can thus lead to an overestimation for the larger region. In addition ammonia is efficiently dry and wet deposited and so a very steep gradient in ammonia concentrations develops in coastal areas.

It is, therefore, questionable to extrapolate land-based measurements of reduced nitrogen concentrations and give them extended representativity over the sea. For these reasons the extrapolation estimates  $D_w^X$  and  $D_w^H$  are likely overestimations.

The reliability of model results is in general dependent on the quality of the input data. The better the model - the higher the requirement for good and reliable data. It is difficult to give an overall range of uncertainty for the results, but since the uncertainty of the input data over sea areas is larger than for land, the same must be true for the model results. In addition, the present models tend to overestimate depositions in Central Europe relative to measured depositions and to underestimate them in the fringe areas such as Scandinavia.

As for the calculations of reduced nitrogen it should be recalled that the main part of the emission data for ammonia is based on unofficial estimates that have not been updated since 1985. It should also be noted on one hand that the model underestimates the ammonium concentration in precipitation for some sites in the Baltic region (Iversen et al., 1989) even though the bulk of the measurement sites compare well with the model concentrations. On the other hand the MSC-W-model does calculate the coastal ammonia concentration gradient.

With these comments and reservations on the various methods of estimation the nitrogen deposition to the Baltic Sea may be assessed as follows:

The experimental and hybrid values  $D_w^X$  and  $D_w^H$  probably overestimate the wet deposition of reduced nitrogen.

The model value  $D_T^{M-W}$  probably underestimates the same quantity.

For oxidized nitrogen the deposition estimates  $D_w^X$  and  $D_w^H$  are probably overestimates whereas the model estimate  $D_T^M$  that includes dry deposition is considered fairly realistic.

A reasonable estimate for the total deposition of nitrogen to the Baltic Sea in the latter half of the 1980's thus seems to be

300 000 ± 30 000 Tonnes N/yr

## 7. TRACE METAL DEPOSITION

The measurement of trace metal contents in precipitation has in the period considered only been performed on an experimental or voluntary basis and such measurements have only been part of the routine minimum requirement programme of EGAP since 1990. The database is therefore small and the data quality is in some doubt as described in Chapter 3. This chapter is therefore primarily concerned with results for lead.

### 7.1. Experimental Estimates

The wet deposition of Pb is estimated as for the nitrogen compounds, i.e. on the basis of the precipitation weighted mean concentrations  $c_s$  measured at the stations s and shown in Table 5.2.5. The calculations proceed by the same two methods used for nitrogen and thus the annual deposition fluxes are obtained as a first step.

#### 7.1.1. Wet Deposition Fluxes

The experimental Pb fluxes at the few measuring stations are shown in Table 7.1.1. As for nitrogen the values tend to fall off towards the north of the Baltic region, but the quality of the data is not good enough to reveal the expected decrease with time due to diminishing emissions of leaded gasoline.

**Table 7.1.1. Wet deposition station fluxes  $F_{ws}^X$  of lead (g Pb/km<sup>2</sup> yr).**

	1986	1987	1988	1989	1990	1986-90
Hailuoto	1275	1024	1253	2644	5911	2422
Haapasaari	2341	2655	1944	7988	3525	3690
Vanhankylänmaa	3095	1732	3036			2621
Aspvreten	2730	1535	2188	1615		2017
Arup	5227	2048	3406	1977		3165
Leba			8431	7351	5258	7013
Dänisch-Nienhof	3933	4033	2230			2549
Baltic Sea Average	2390	2147	3285	4072	4898	3354

The experimental sub-basin fluxes  $F_{wb}^X$  to the sub-basins are calculated from the station fluxes as described earlier but as the sub-basins are represented by only one or two stations the results are quite uncertain.

The hybrid fluxes  $F_{wb}^H$  are calculated in the usual way on the basis of the concentrations at the few stations and they are therefore also of limited validity. The 5-year average values of the two sets of annual sub-basin fluxes are shown in Table 7.1.2. as well as the area weighted total fluxes to the whole Baltic Sea.

**Table 7.1.2. Average wet fluxes of lead for the years 1986\*-1990 and their average ratios (g Pb/km<sup>2</sup> yr).**

Sub-basin	$F_{wb}^X$	$F_{wb}^H$	$F_w^H / F_w^X$
A <sub>1</sub> Gulf of Bothnia	2422	3622	1.50
A <sub>2</sub> Gulf of Finland	3783	6782	1.79
A <sub>3</sub> Baltic Proper, North	2017	1534	0.76
A <sub>4</sub> Baltic Proper, South	4464	4561	1.02
A <sub>5</sub> Belt Sea and Kattegat	2549	3464	1.36
A <sub>0</sub> Baltic Sea Average	3047	3993	1.31

\*) For 1986 the average values of  $P^H$  for 1987-1990 have been used.

As for nitrogen the hybrid fluxes are the larger, except in the central sub-basin A<sub>3</sub>, and the ratios also exhibit the same geographical variation. The expected decrease towards the north can just be seen but in the experimental estimates only.

#### 7.1.2. Wet Deposition Estimates

On the basis of the deposition fluxes the wet deposition to the basins can now be estimated by the two methods.

$$D_{wb}^X = A_b \cdot F_{wb}^X$$

$$\text{and } D_{wb}^H = A_b \cdot c_b \cdot P_b^H = A_b \cdot F_{wb}^H$$

Here the experimental deposition  $D_w^X$  is based on extrapolation of measurements of both concentrations and precipitation at the EGAP stations. The hybrid deposition  $D_w^H$  is based on concentration measurements at the EGAP stations and on NWP model calculations for precipitation over the sea.

The wet depositions for Pb are shown for all years and all basins in Tables 7.1.3 - 7.1.4. The experimental results show that possibly the deposition of lead to the Baltic Sea has been decreasing during the latter half of the 1980s. Such a trend is not, however, to be seen in the hybrid estimates.

**Table 7.1.3. Annual wet sub-basin depositions  $D_{wb}^X$  of lead (T Pb/yr).**

Sub-basin	1986	1987	1988	1989	1990	1986-90
A <sub>1</sub> Gulf of Bothnia	147	118	145	305	683	280
A <sub>2</sub> Gulf of Finland	80	65	73	236	104	112
A <sub>3</sub> Baltic Proper, North	455	256	365	270		269
A <sub>4</sub> Baltic Proper, South	319	125	361	285		218
A <sub>5</sub> Belt Sea and Kattegat		167	171	95		86
A <sub>0</sub> Baltic Sea Total	1007	731	1115	1190	787	965

**Table 7.1.4.** Annual wet sub-basin depositions  $D_{wb}^H$  of lead (T Pb/yr).

Sub-basin	1986*	1987	1988	1989	1990	1986*-90
A <sub>1</sub> Gulf of Bothnia	190	137	211	381	1226	429
A <sub>2</sub> Gulf of Finland	116	75	107	486	232	203
A <sub>3</sub> Baltic Proper, North	389	248	344	323		261
A <sub>4</sub> Baltic Proper, South	311	124	294	324	324	275
A <sub>5</sub> Belt Sea and Kattegat		169	158	115	146	117
A <sub>0</sub> Baltic Sea Total	1005	747	1114	1630	1929	1285

\*) For 1986 the average values of P<sup>H</sup> for 1987-1990 have been used.

The discrepancies between the annual values of these two sets of deposition estimates are considerable, emphasizing the questionable quality of the data.

The average sub-basin depositions  $D_w^X$  and  $D_w^H$  for the 5 years 1986-1990 are shown in *Table 7.1.5*.

**Table 7.1.5.** Average depositions of lead for the years 1986\*-1990 and their average ratios (T Pb/yr).

Sub-basin	$D_{wb}^X$	$D_{wb}^H$	$D_w^H / D_w^X$
A <sub>1</sub> Gulf of Bothnia	280	429	1.53
A <sub>2</sub> Gulf of Finland	112	203	1.82
A <sub>3</sub> Baltic Proper, North	269	261	0.97
A <sub>4</sub> Baltic Proper, South	218	275	1.26
A <sub>5</sub> Belt Sea and Kattegat	86	117	1.35
A <sub>0</sub> Baltic Sea Total	965	1285	1.33

\*) For 1986 the average values for 1987-1990 have been used.

The ratios vary geographically as seen before and it is therefore presumably an effect of the methods used to estimate precipitation over the sea. But the ratios are considerably larger than for nitrogen, reflecting the uncertainty of the results and possibly also bias introduced by representing the sub-basins with only one or two stations.

### 7.1.3. Total Deposition Estimates

Estimates of the type D<sup>X</sup> have been calculated for total deposition of a number of trace metals in 1985-1987 by Schneider (1988). The method differed slightly from the ones used above and dry deposition was accounted for either by using bulk deposition data when available or by assuming that dry deposition amounts to 25 % of the total. This latter approximation is very crude. The deposition over the sea was approximated by multiplication of depositions at the stations with model derived extrapolation factors. The same method has been applied to newer data so the results are valid for the years 1986-1989. Both sets of results are shown below in *Table 7.1.6*. The differences are considerable, the largest ones are found in the Baltic Proper South and they may reflect the uncertainties introduced by these approximations.

**Table 7.1.6.** Annual total deposition  $D_T^X$  of atmospheric trace metals to the Baltic Sea (T/yr). (Calculations by Schneider 1988, and personal communication).

Sub-basin	Pb	Cd		Zn		Cu
	1987	1986-89	1985-87	1986-89	1985-87	1986-89
A <sub>1</sub> Gulf of Bothnia	183	270	11	14	1652	2660
A <sub>2</sub> Gulf of Finland	80	101	9	9	315	286
A <sub>3</sub> Baltic Proper, North	427	560	19	27	1361	1295
A <sub>4</sub> Baltic Proper, South	148	416	7	17	607	1058
A <sub>5</sub> Belt Sea and Kattegat	189	255	10	10	806	598
A <sub>0</sub> Baltic Sea Total	1027	1600	57	77	4741	5900
						1205

A comparison with *Tables 7.1.3-7.1.5* shows that the total deposition derived from bulk measurements leads to considerably higher values in the two wide sub-basins, Baltic Proper North and South.

## 7.2. Model Estimates for Lead Deposition

Model calculations of trace element depositions have been carried out by the German research institute GKSS (Petersen et al., 1989). The model is a trajectory model with a similar structure as that of MSC-W. However no physical or chemical transformation is assumed. The calculations have been restricted to lead for the period 1980-1985 because emission databases in the EMEP-grid for other metals is still in a very preliminary stage. Emission data have been set up for lead in a R & D project of the German Environmental Agency carried out by Dornier with support of the EMEP Chemical Coordinating Center.

Annual means of atmospheric lead concentrations and dry, wet, and local deposition fluxes for the year 1985 are shown in *Figures 7.2.1 - 7.2.4*. Because of the predominantly low emission heights (automobiles) it has been assumed that 15 % of the emitted lead is deposited in the local emission grid square. The result is that the total deposition of lead to the Baltic Sea is close to 1400 t Pb/year.

The monthly total, wet, dry, and local deposition of lead to the Baltic Sea during 1985 is shown in *Figure 7.2.5*. The monthly variation of the total lead input is mainly due to the variation of precipitation because wet deposition is the dominant pathway.

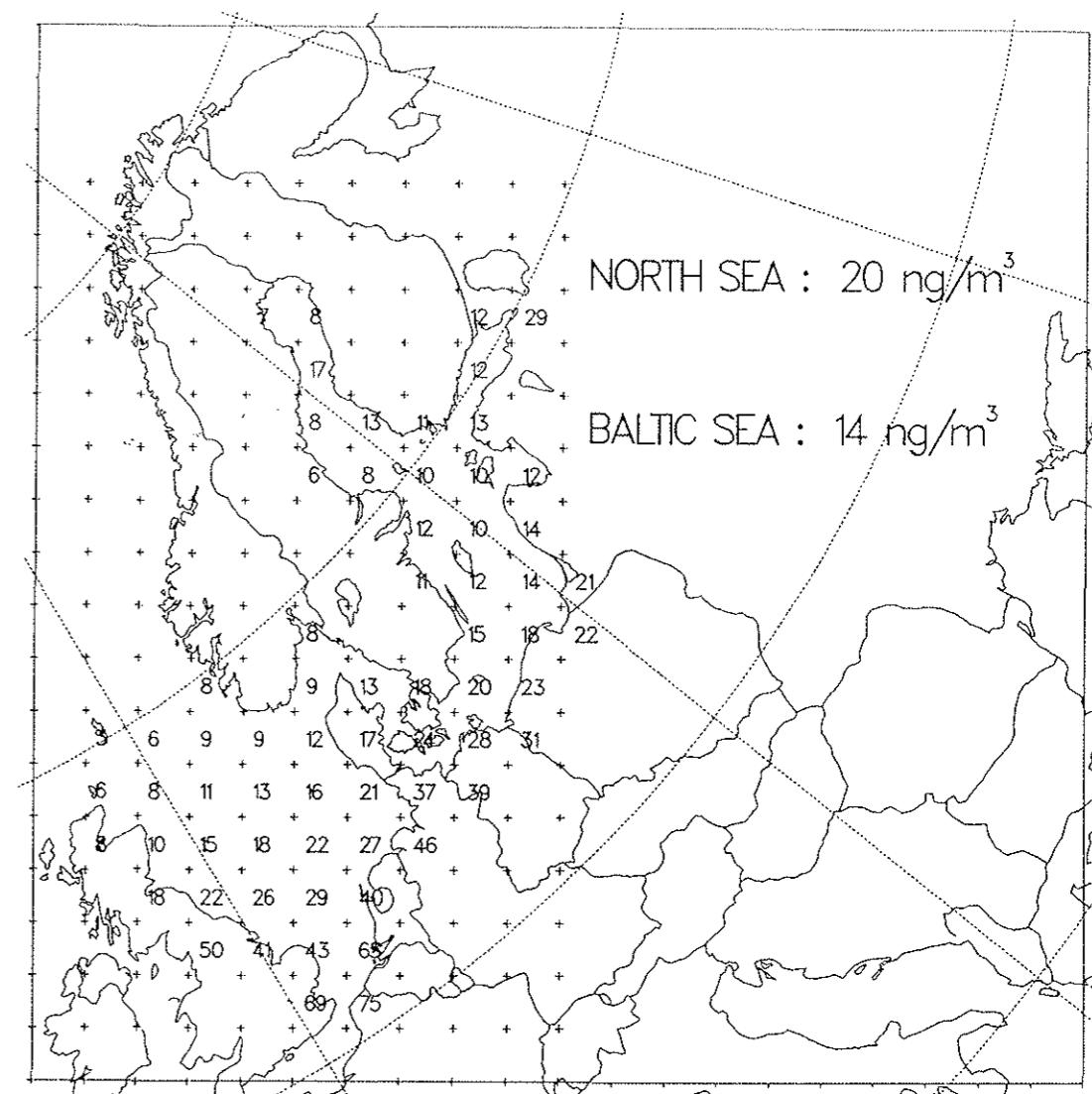
The annual deposition of lead to the Baltic Sea due to emissions in 1984-1985 from different European countries is shown in *Table 7.2.1*. About 70 % of the input is caused by the riparian countries around the Baltic Sea, the rest is due to long range atmospheric transport from other areas in Europe.

Model results have been checked with the available data for lead concentrations in precipitation from the representative EGAP-monitoring stations for the five sub-basins. The stations have been implemented into the model as arrival points for trajectories so that a direct comparison between measured and calculated data could be performed.

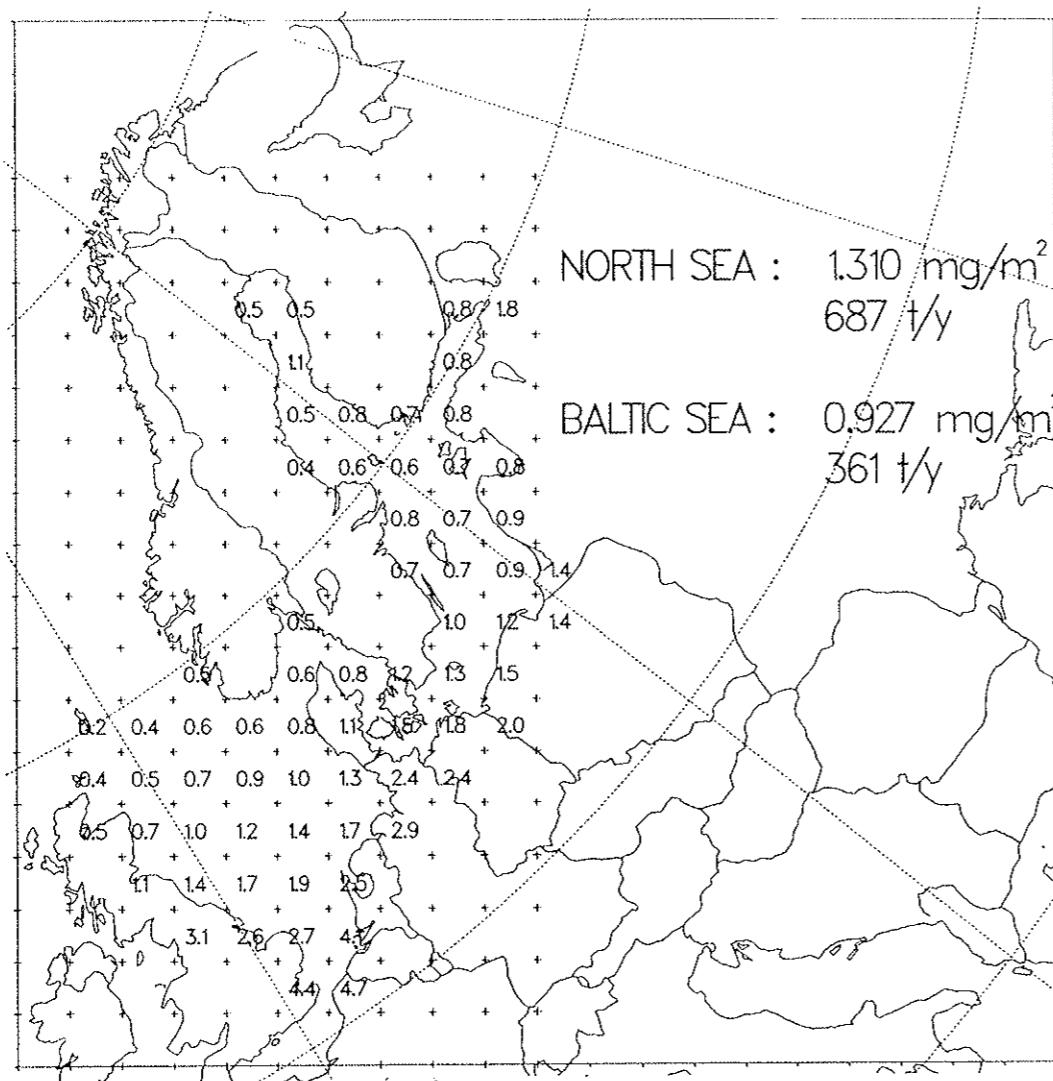
However, at present the time series of measured precipitation and monthly mean bulk concentrations can be compared on a limited basis only due to gaps in the data from the monitoring stations. An example is shown in *Figure 7.2.6*. The overall agreement in terms of mean annual concentrations is reasonable but it seems that at most stations the model is unable to predict the concentration peaks. There is a tendency to increased model underpredictions from south to north i.e. from areas relative close to the sources to remote locations.

Measurement data on lead concentrations in air and dry deposition fluxes are not available from stations reporting to HELCOM in 1985, so that those two model output parameters could not be verified for that year. Measured and calculated air concentrations at Kiel Bight for 1982, however, showed a good agreement even on a weekly mean basis (Petersen et al., 1989).

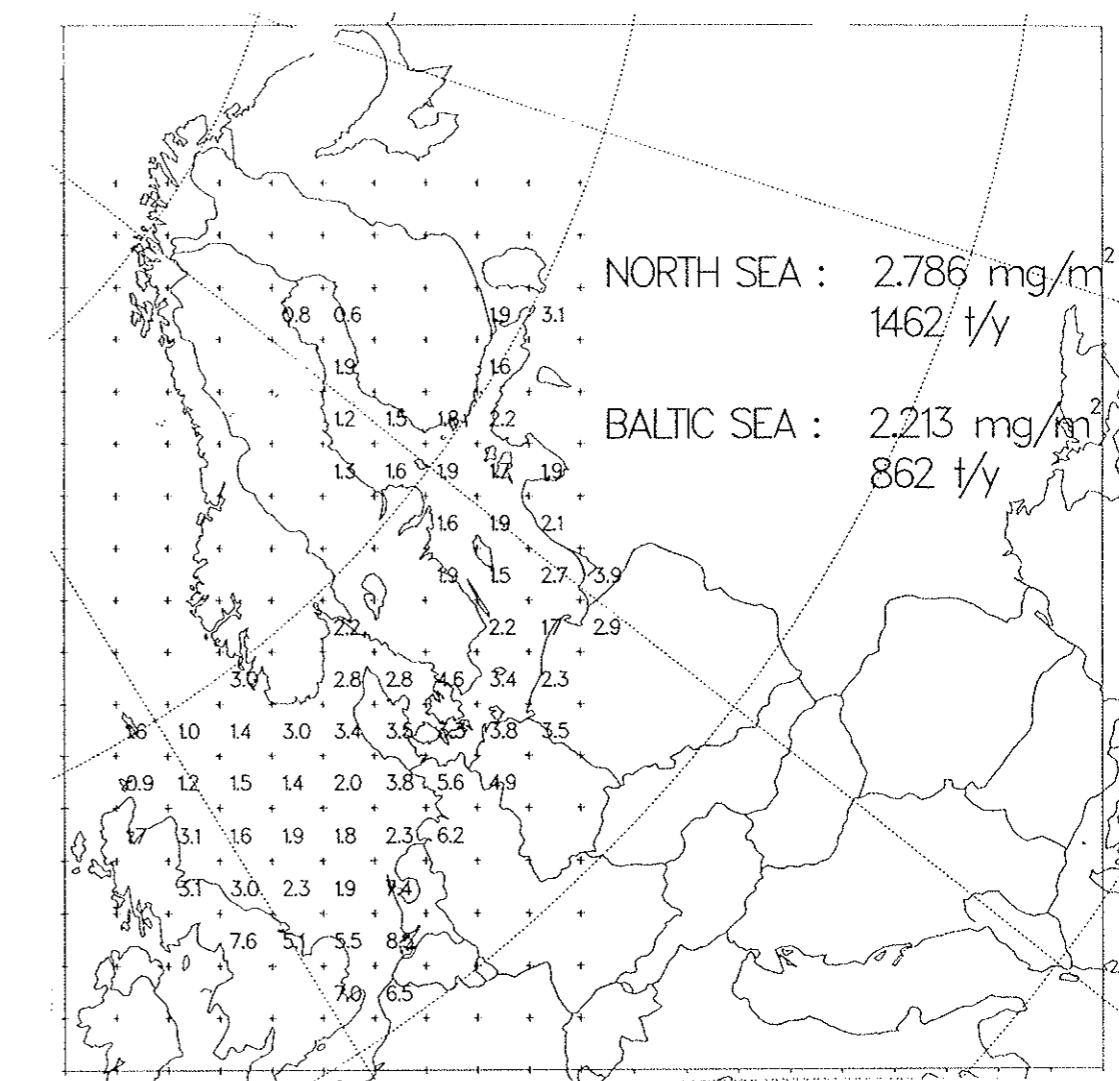
**Figure 7.2.1. Concentrations of lead in air 1985.**



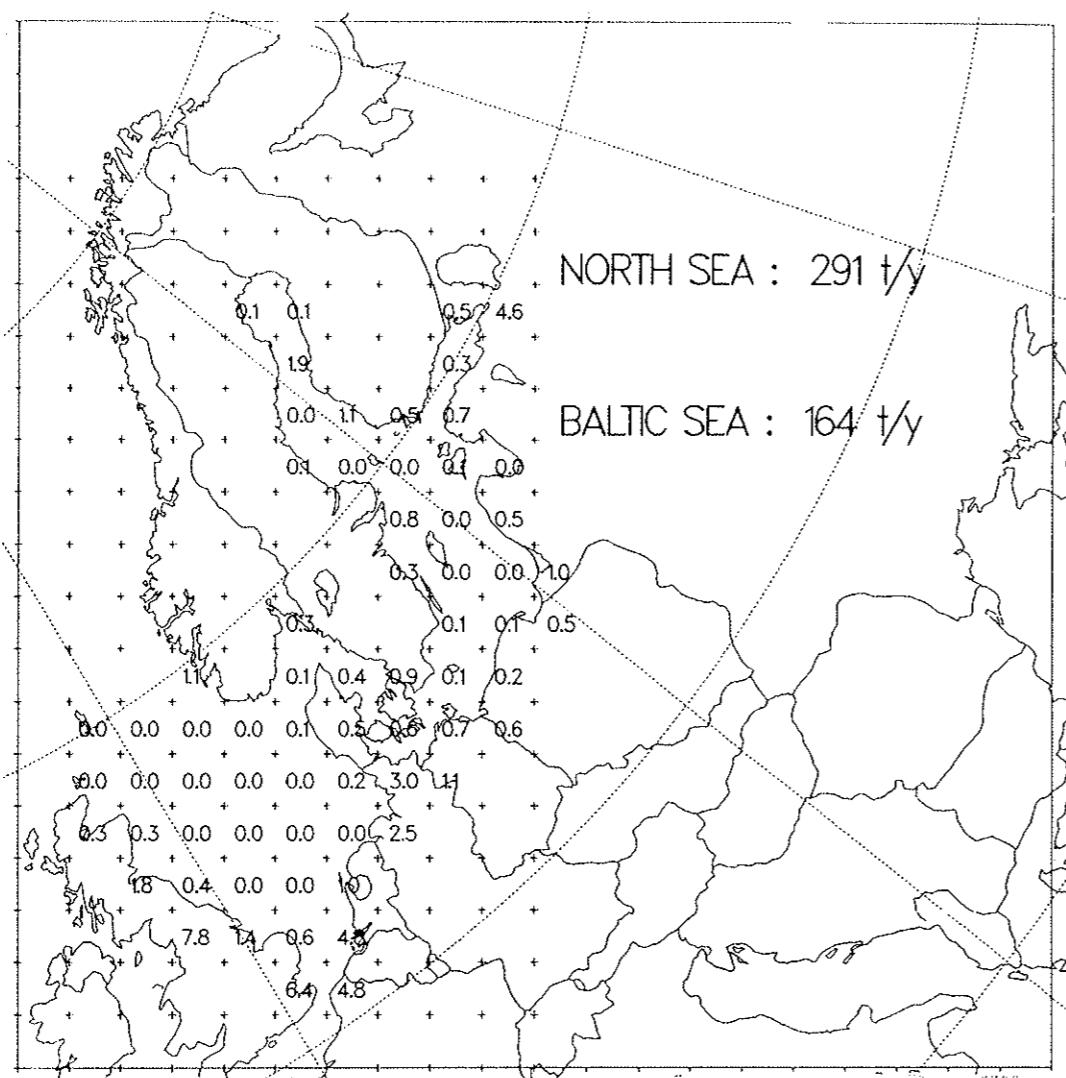
**Figure 7.2.2.** Dry deposition of lead in 1985.



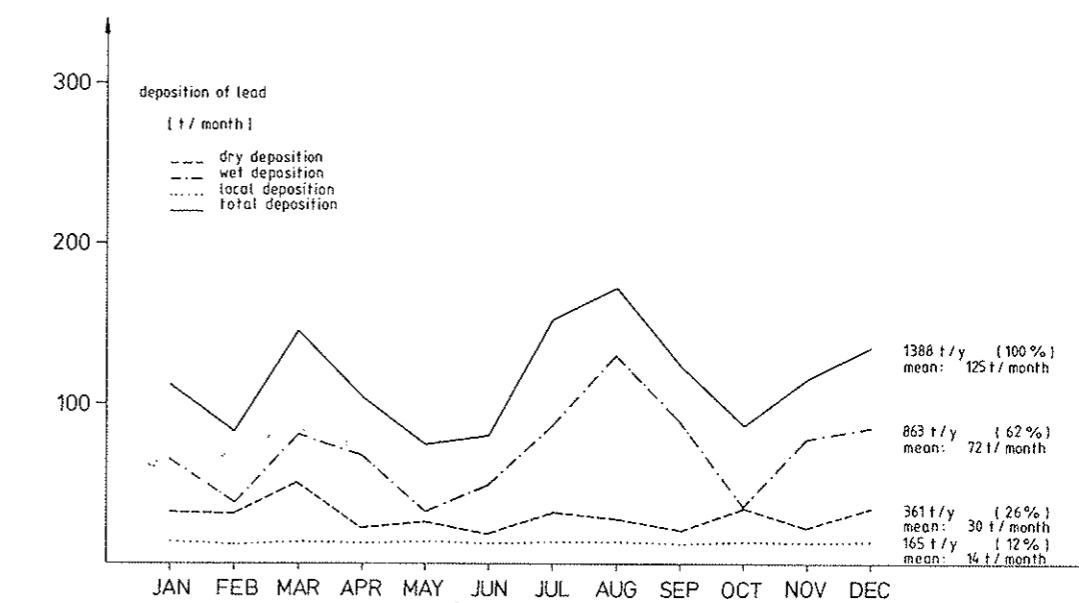
**Figure 7.2.3.** Wet deposition of lead in 1985.



**Figure 7.2.4.** Local deposition of lead in 1985.



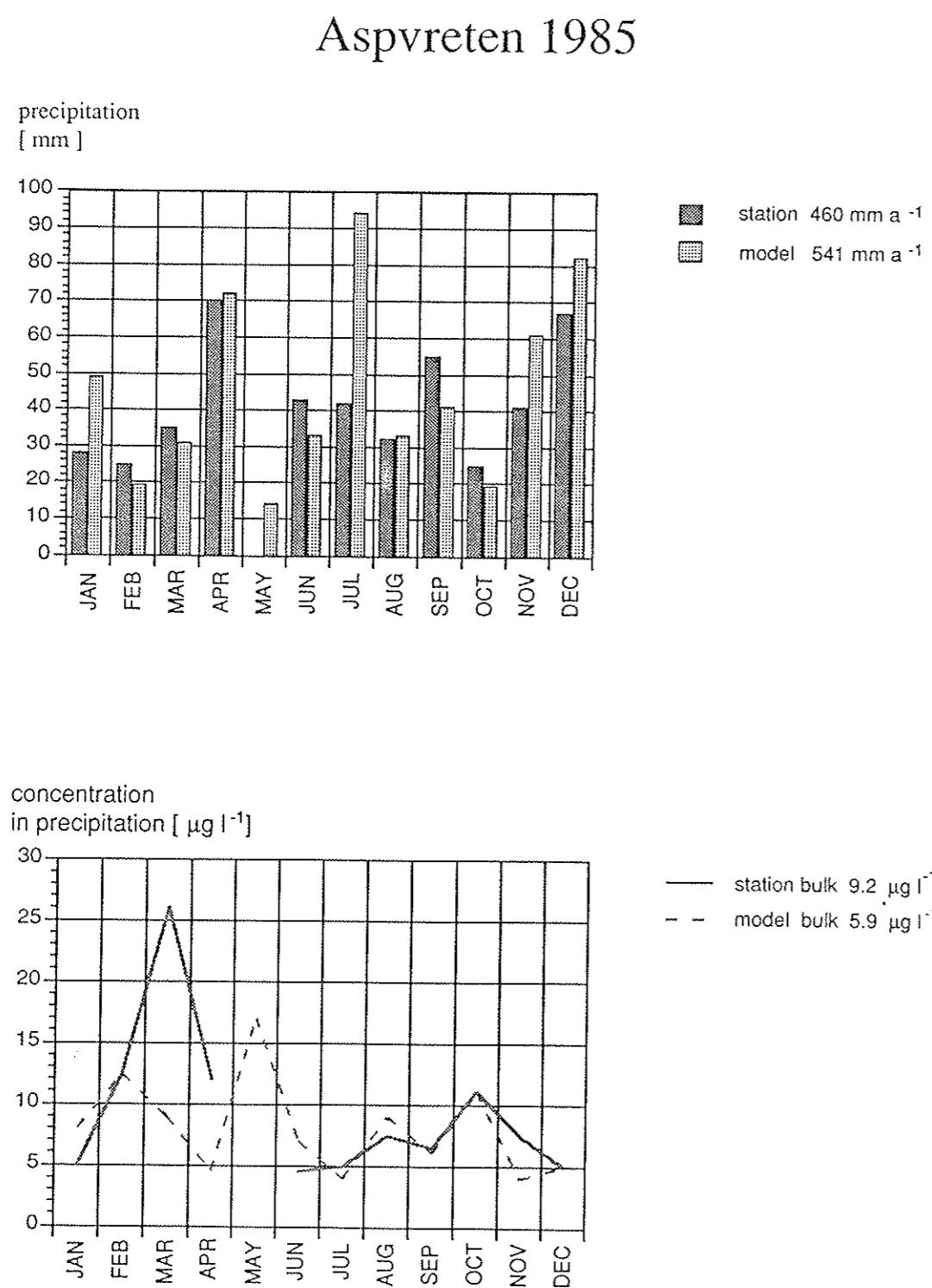
**Figure 7.2.5.** Monthly total, wet and dry deposition of lead to the Baltic Sea in 1985.



**Table 7.2.1.** Contributions of European countries to the lead deposition in the Baltic Sea in 1984-1985 (T Pb/yr).  
HELCOM member countries are marked with an asterisk (\*).

	T Pb/yr
BE	44
DK*	57
FI*	104
FR	96
DD*	101
DE*	205
NL	82
NO	14
PL*	118
SE*	139
SU*	221
GB	130
Others	76
<b>SUM</b>	<b>1387</b>

**Figure 7.2.6.** Monthly precipitation amounts and concentrations of lead in bulk deposition.  
Aspvreten 1985.



### 7.3 Assessment of Lead Deposition

The estimates of annual lead deposition to the Baltic Sea as extrapolations of measurements and as model calculations by GKSS are summarized in *Table 7.3.1*. The variation of up to 60 % among these results is considerable. The reasons for that are on one hand that the quality of the measurement data is not good enough and that in some cases quite crude approximations have been used to extrapolate measurement results out over the sea and on the other hand that the emission inventories used for model calculations are in need of improvement. Thus, the emission inventory used must be considered obsolete since it probably contains lead emission figures from the early 1980s when the use of leaded gasoline was still widespread. More consistent deposition estimates obviously require additional refinements in extrapolation techniques for measurement data and model parameterizations.

The comparison of model results and measured concentrations in bulk deposition has shown that the model tends to underestimate this parameter and hence total deposition. On the other hand the extrapolation method used to derive sub-basin dry and wet deposition fluxes from precipitation concentrations at individual stations may very well overestimate the total deposition  $D_T^X$ .

**Table 7.3.1.** Annual deposition of lead to the Baltic Sea.

Period	Type	Ref.	t/yr
1986-1990	$D_w^X$ , wet	This work	965
1986-1990	$D_w^H$ , wet	This work	1285
1986-1989	$D_T^X$ , total	Schneider, 1988	1600
1987	$D_T^X$ , total	Schneider, 1988	1030
1985	$D_T^M$ , total	Petersen et al., 1989	1390

With these comments and reservations on the various methods of estimation the lead deposition to the Baltic Sea may be assessed as follows:

The experimental and hybrid values for wet depositions,  $D_w^X$  and  $D_w^H$ , are very uncertain.

The experimental values for total deposition,  $D_T^X$ , are probably overestimates.

The model value for total deposition,  $D_T^M$  is probably an underestimate.

A reasonable estimate for the total deposition of lead to the Baltic Sea in the latter half of the 1980's thus seems to be

$$1300 \pm 250 \text{ Tonnes Pb/yr}$$

## REFERENCES

- Buijsman, E., Maas, J.F.M. and Asman, W.A.H., 1985. Ammonia emissions in Europe. Instituut voor Meteorologie en Oceanografie, Rijksuniversiteit Utrecht. Report IMOU-R-85-2.
- Buijsman, E., Maas, J.F.M. and Asman, W.A.H., 1987. Anthropogenic NH<sub>3</sub> emissions in Europe. *Atmos. Environ.* 21, 1009-1022.
- Climatological Ice Atlas*, 1982. Swedish Meteorological and Hydrological Institute, Norrköping, and Institute of Marine Research, Helsinki. 220 pp.
- Eliassen, A. and Saltbones, J., 1983. Modelling of Long-Range Transport of Sulphur over Europe: A Two-Year Model Run and Some Model Experiments. *Atmospheric Environment* 17, 1457-1473.
- HELCOM, 1986. Water balance of the Baltic Sea. *Balt. Sea Environ. Proc.* No. 16: 1-174.
- HELCOM, 1987. First Baltic Sea Pollution Load Compilation. *Balt. Sea Environ. Proc.* No. 20.
- HELCOM, 1989. Deposition of Airborne Pollutants to the Baltic Sea Area 1983-1985 and 1986. *Balt. Sea Environ. Proc.* No. 32.
- HELCOM, 1991. Intercomparison of precipitation collectors for chemical analyses, HELCOM intercalibration - 2nd stage, Aspvreten, Sweden; Winter 1987 - Autumn 1988. (manuscript)
- Iversen, T., Saltbones, J., Sanders, H., Eliassen, A. and Hov, Ø., 1989. Airborne Transboundary Transport of Sulphur and Nitrogen over Europe: Model Descriptions and Calculations. EMEP-MSC-W Report 2/89.
- Iversen, T., Halvorsen, N.E., Saltbones, J. and Sandnes, H., 1990. Calculated Budgets for Airborne Sulphur and Nitrogen in Europe. EMEP/MSC-W. Report 2/90.
- Joffre, S.M., 1985. The structure of the marine atmospheric boundary layer: a review from the point of view of diffusivity, transport and deposition processes. Techn. Report No. 29, Finnish Meteorol. Inst., Helsinki, 119 pp.
- Kullenberg, G., 1981. Physical oceanography. In: Voipio, A (ed.). *The Baltic Sea*. Elsevier Oceanographic Series 30. Elsevier Scientific Publishing Company, Amsterdam. pp. 133-181.
- Lindfors, V., Joffre, S.M. and Damski, J., 1991. Determination of the wet and dry deposition of sulphur and nitrogen compounds over the Baltic Sea using actual meteorological data. Finnish Meteorological Contributions No. 4. Finnish Meteorological Institute.
- National Swedish Environmental Protection Board, 1989. Atmospheric Trace Metals. Workshop on their Collection and Analysis. SNV Report 3597.
- Pacyna, J.M., 1983. Trace element emission from anthropogenic sources in Europe. Norwegian Institute for Air Research, Report No. 10/92.

- Petersen, G., Weber, H. and Grassl, H., 1989. Modelling the Atmospheric Transport of Trace Metals from Europe to the North Sea and the Baltic Sea. In: J.M. Pacyna and B. Ottar (eds). *Control and Fate of Atmospheric Trace Metals*. NATO ASI Series. Series C: Mathematical and Physical Sciences - Vol 268, pp. 57-83. Kluwer Academic Publishers.
- Ross, H.B., 1989. Report on the Intercalibration of Analytical Methods for the Determination of Trace Metals, Nitrate and Ammonium in the Atmosphere within the Framework of the Baltic Marine Commission of the Helsinki Commission. National Swedish Environmental Protection Board. Report No. 3597, pp. 61-76.
- Salmi, T. and Joffre, S.M., 1988. Airborne pollutant measurements over the Baltic Sea: Meteorological interpretation. Reports 1988: 3. Finnish Meteorol. Inst., Helsinki, pp. 55.
- Schaug, J., 1988. Quality Assurance Plan for EMEP. EMEP CCC Report 1/88.
- Schneider, B., 1988. Input of Atmospheric Trace Metals to the Baltic Sea Area - An Estimate Based on the EGAP (HELCOM) Monitoring Data. (mimeogr.)
- Semb, A. and Amble, E., 1981. Emission of Nitrogen Oxides from Fossil Fuel Combustion in Europe. NILU Technical Report 13/80. Lillestrøm, Norway.
- Voipio, A., ed., 1981. *The Baltic Sea*. Elsevier Oceanographic Series 30. Elsevier Scientific Publishing Company, Amsterdam.

**AIRBORNE POLLUTION LOAD TO THE BALTIC SEA 1986-1990****APPENDICES**

- A. Precipitation in the Baltic Sea Area 1987 - 1990**  
Data from the MSC-W archives
- B. Distribution of Deposition of Oxidized and Reduced Nitrogen to the Baltic Sea in 1988**  
Based on MSC-W model calculations
- C. Nitrogen Compounds: Results on Concentrations, Fluxes, and Depositions**

**APPENDIX A:**

**Precipitation in the Baltic Sea Area 1987 - 1990**  
**Data from the MSC-W archives**

In the assessment of the deposition of air pollutants to the Baltic Sea, it is of great importance to get a reliable picture of the precipitation amount and also the spatial and temporal variation.

A large fraction of the deposition load follows the wet-deposition route to the sea surface and to a first approximation, the deposition load will be proportional to the precipitation amount.

There are very few measurement stations with long records of observations over the open sea. In addition, it is very difficult to get reliable and representative measurements in wind-exposed conditions. Research programmes aimed at reducing the uncertainty in precipitation measurements over sea areas, should be given high priority. Remote sensing techniques, such as use of radar and micro-wave observations from satellites, and observations from oil rigs may in future give more reliable estimates and with lower uncertainty.

The best estimates that can be given at the moment, are based on a combined procedure using routine weather observations (SYNOPS) from measurement sites at islands and nearby land areas, together with model calculations for the more open sea regions. At the Meteorological Synthesizing Centre-West of EMEP, this procedure is used to construct the precipitations fields used in the EMEP/MSC-W model calculations for transboundary fluxes of sulphur and nitrogen compounds in Europe.

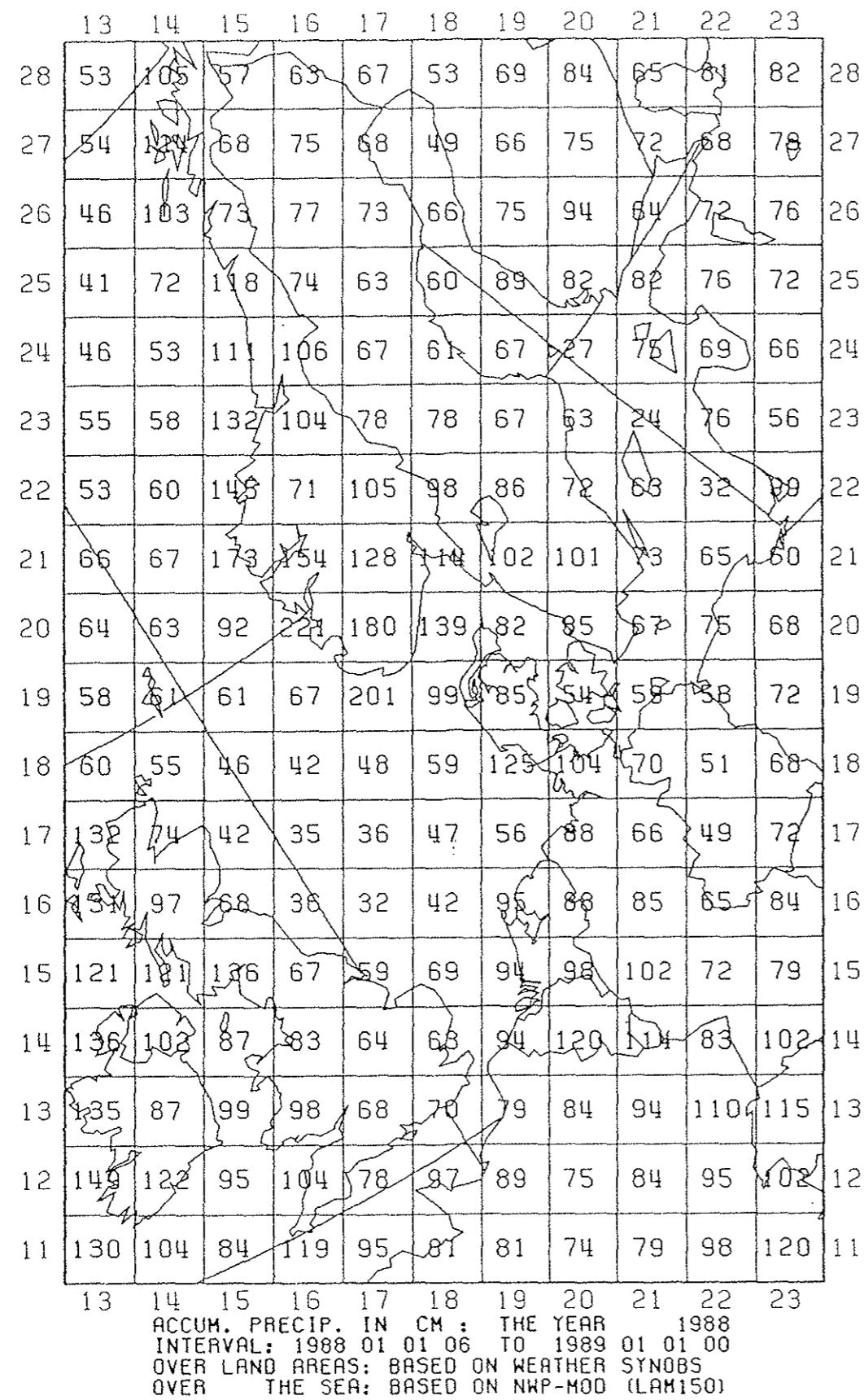
The precipitation fields are represented by grid squares, 150 x 150 km<sup>2</sup>, and the values should give a representative value for that area. If a grid square is dominated by land-areas, the value for the precipitation amount is taken from the field constructed on the basis of the routine weather observations (SYNOPS). If, on the other hand, the grid square covers mostly sea areas, the value for the precipitation amount is taken from the field constructed by the LAM150 (Limited Area Model, 150 km grid resolution) numerical weather prediction model.

LAM150 is a numerical weather prediction model, run in routine mode at the Norwegian Meteorological Institute. The data produced by this model, form the basis for the archive of meteorological data used/stored by the MSC-W of EMEP.

From these archived 6 hourly precipitation fields, monthly and yearly precipitation fields have been constructed for the period 1987-1990. For the 4 years, the procedure of producing these fields has been unchanged and the data produced are uniform with no gaps or discontinuities.

*Figure A.1 shows an example of the result of the accumulation of such precipitation fields, covering the year 1988.*

**Figure A.1.** Model estimates for the distribution of precipitation in 1988.  
Units: cm.



#### A.1. Yearly Precipitation Amount in 5 Sub-Regions of the Baltic

The sub-regions are denoted as Area 1, 2, 3, 4, 5. Area-weighted mean yearly values for each sub-region,  $(\bar{P})$ , have been calculated from the yearly precipitation maps. To assess the interannual variability, the differences found between these four yearly values, have also been calculated,  $\Delta$ , as well as the relative difference,  $\Delta/(\bar{P})$ . The results are given in *Table A.1*.

**Table A.1.** Precipitation Amount in the Baltic Sea  
Period: 1987-1990

	Mean $(\bar{P})$ [mm]	Difference $\Delta$ [mm]	Relative Difference $\Delta/(\bar{P})$ %	Area Size $[10^3 \text{ km}^2]$	1988-values [mm]
Area 1	635	73	12	~115.15	623
Area 2	729	108	15	~29.5	706
Area 3	523	118	23	~166.8	559
Area 4	679	116	17	~61	665
Area 5	747	201	27	~42.4	758
Total Baltic Sea Area	615	106	17	415.3	623

#### A.2. Annual Variation in Monthly Precipitation

To assess the variation in precipitation amount over the year, one grid square in each of the 5 sub-regions has been taken out to exemplify the conditions in that region, and monthly values have been calculated for the period.

##### Comments and conclusions

From *Table A.1.* it is seen that ~25% more precipitation is falling in the southern and western parts of the Baltic Sea (areas 4 and 5), than in the northern and central parts (areas 1 and 3).

The inter-annual variability is largest around Denmark (area 5, with 27%) and in the central part of the Baltic (area 3, with 23%), see *Table A.1.*

Less precipitation is falling over the sea than over nearby land area, ~15% less. Most pronounced is this effect in area 3, with about  $\frac{2}{3}$  of the precipitation in nearby land area.

From *Table A.1.* it may be seen that 1988 was a typical year concerning precipitation in the Baltic Sea area, and also in the sub-areas.

In general April-May are the months giving the smallest amount of precipitation, ~30 mm/month. July-September is the wettest part of the year, ~75 mm/month.

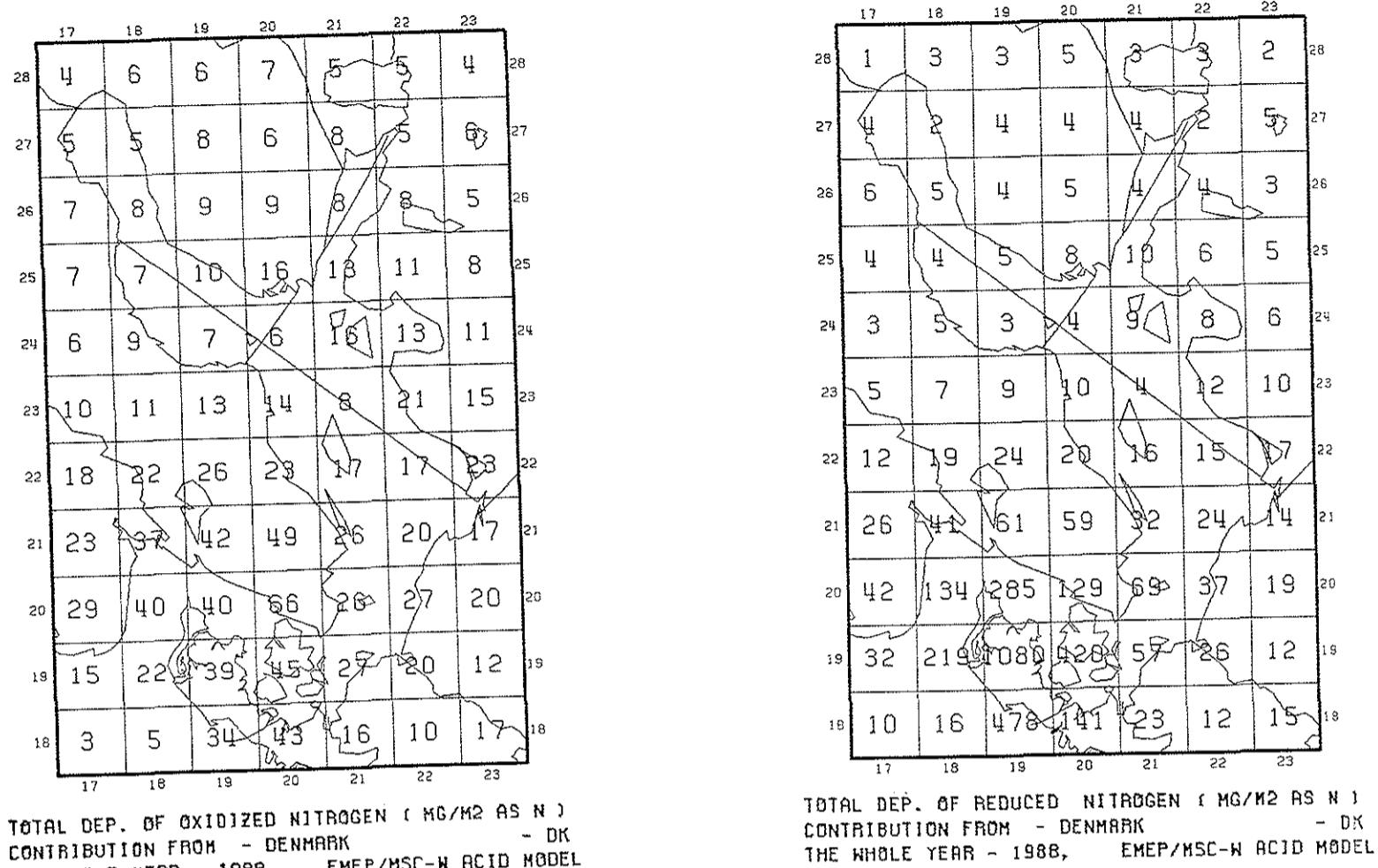
##### Some reservations:

It is suspected that the LAM150 model gives slightly less precipitation than observed. It is difficult to verify this statement because reliable data representative for open sea areas are lacking. The area with minimum precipitation ( $A_3$  - Central Baltic) is the area most influenced from the model calculations. The other areas are more strongly influenced by observations from surrounding land areas.

#### APPENDIX B:

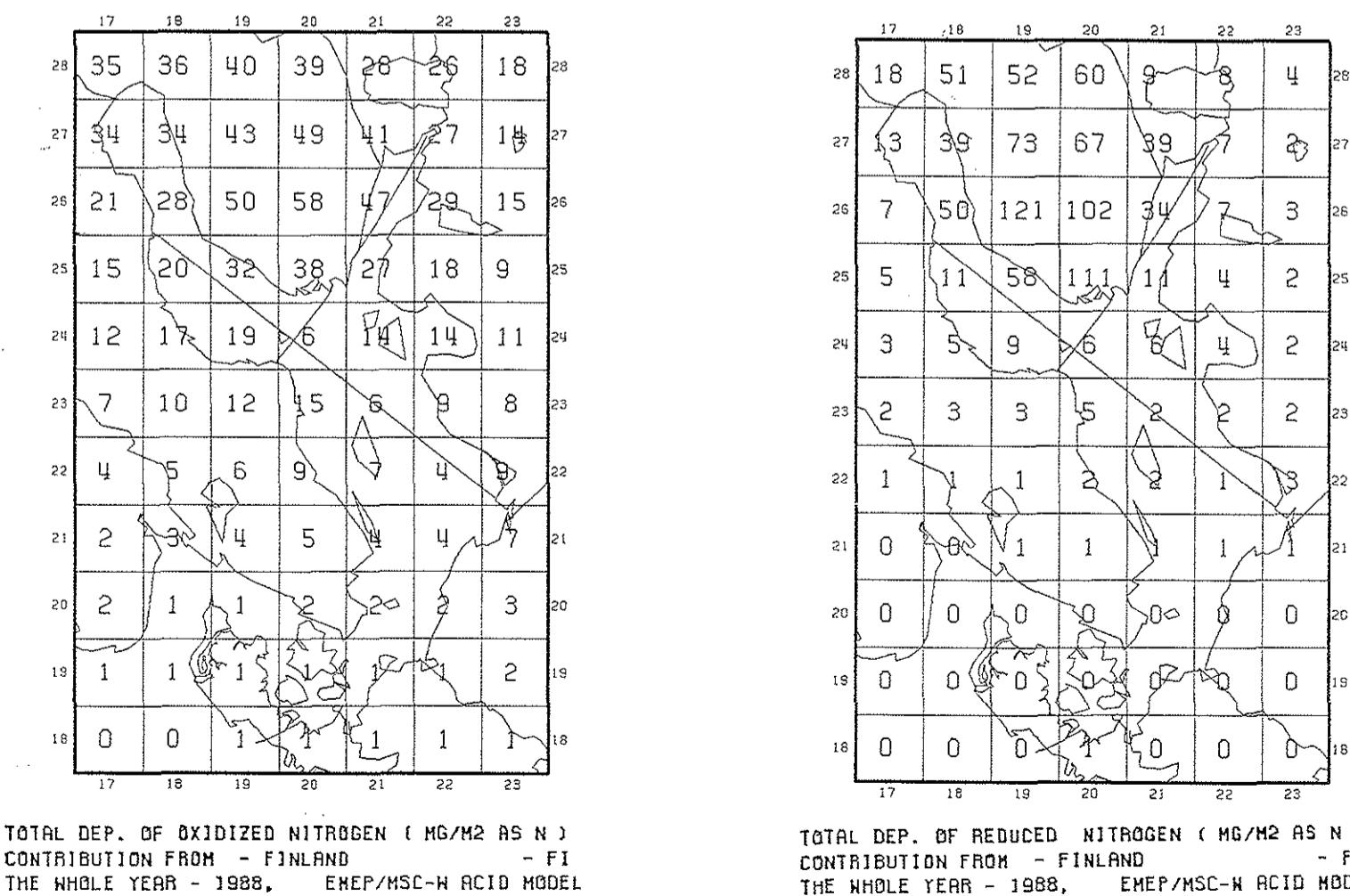
#### Distribution of Deposition of Oxidized and Reduced Nitrogen to the Baltic Sea in 1988 Based on MSC-W model calculations

Figure B.1.



70

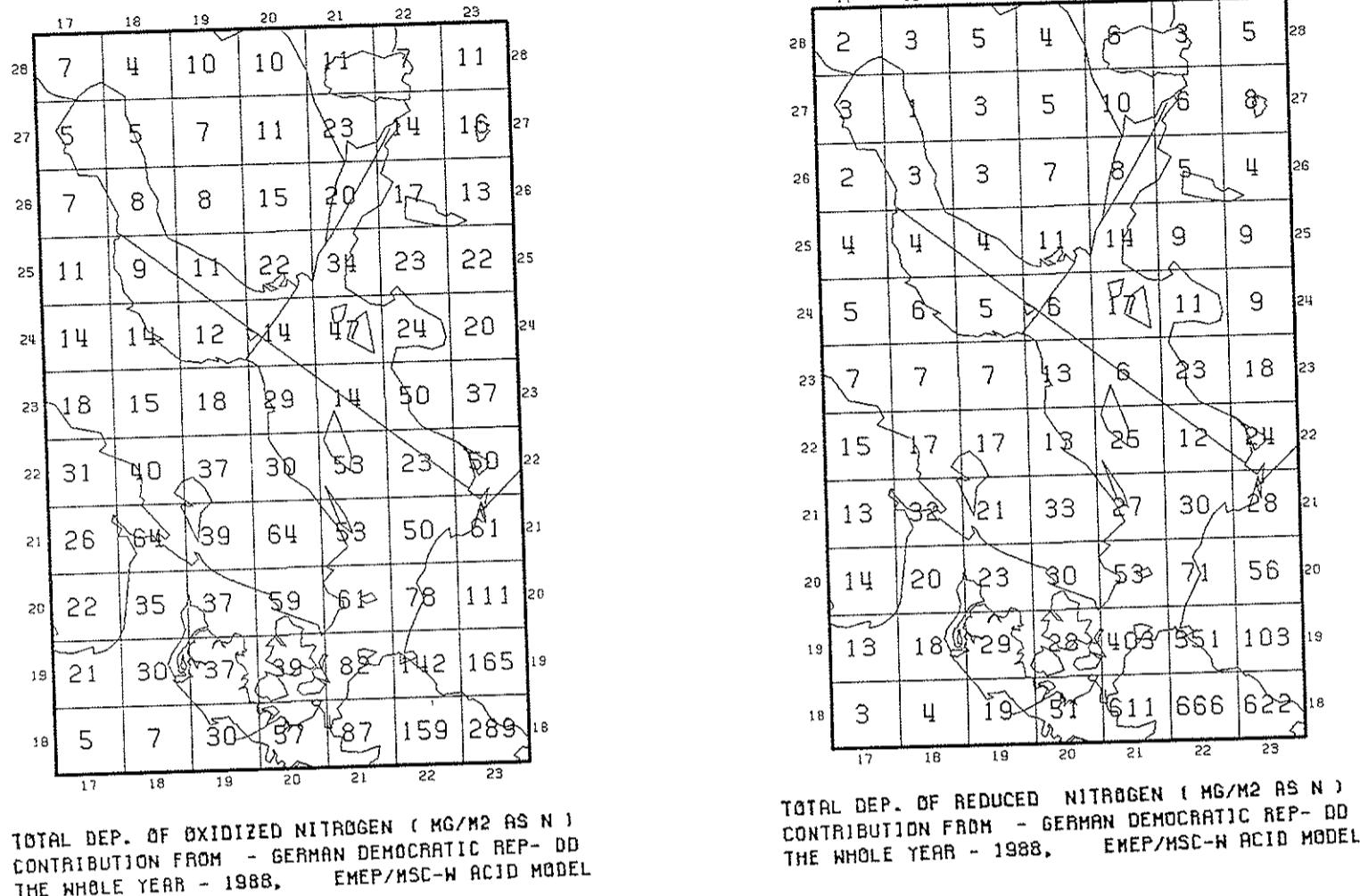
Figure B.2.



71

Figure B.3.

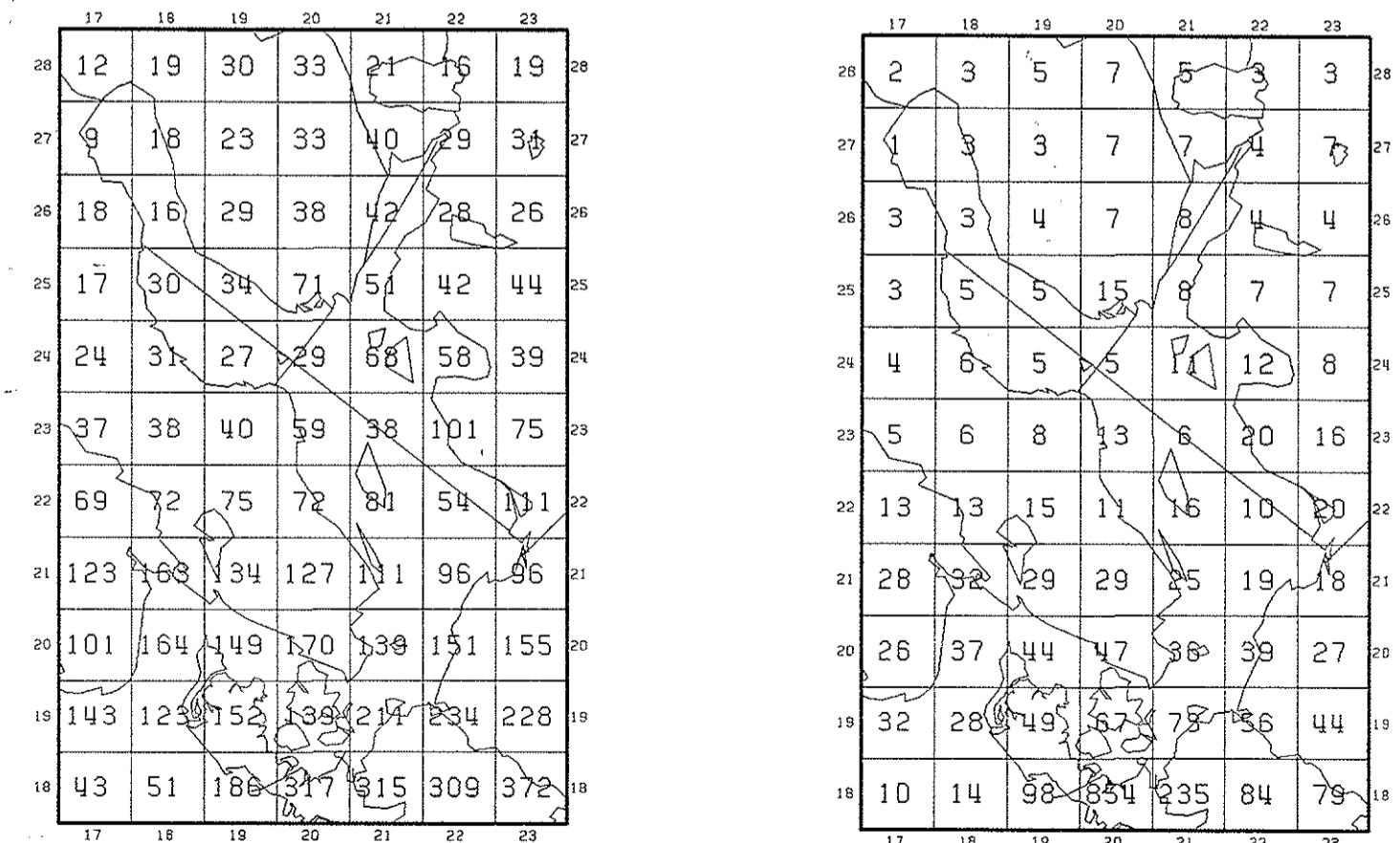
72



TOTAL DEP. OF REDUCED NITROGEN ( MG/M<sup>2</sup> AS N )  
CONTRIBUTION FROM - GERMAN DEMOCRATIC REP- DD  
THE WHOLE YEAR - 1988, EMEP/MSC-W ACID MODEL

Figure B.4.

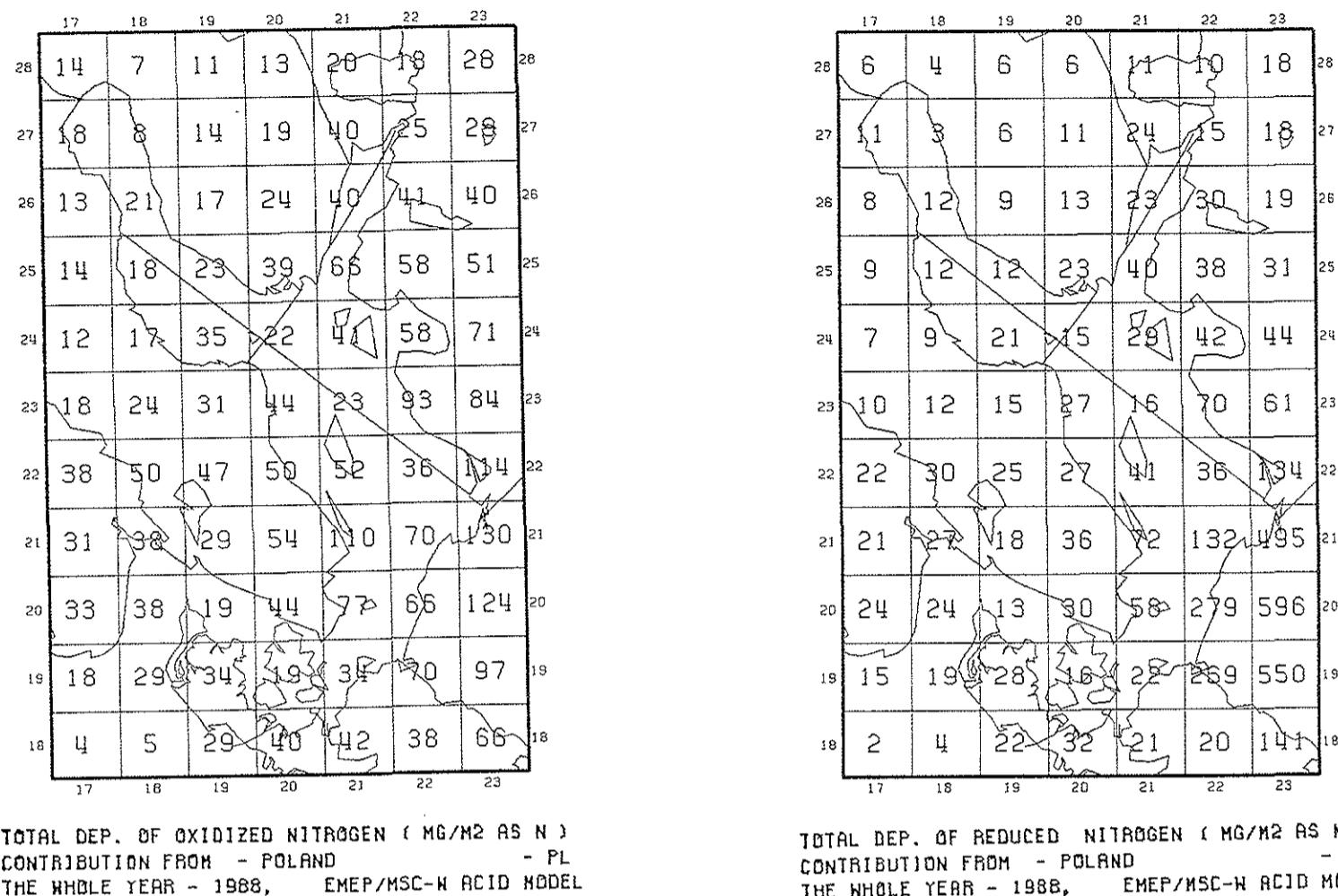
73



TOTAL DEP. OF REDUCED NITROGEN ( MG/M<sup>2</sup> AS N )  
CONTRIBUTION FROM - GERMANY, FEDERAL REP.- DE  
THE WHOLE YEAR - 1988, EMEP/MSC-W ACID MODEL

Figure B.5.

74

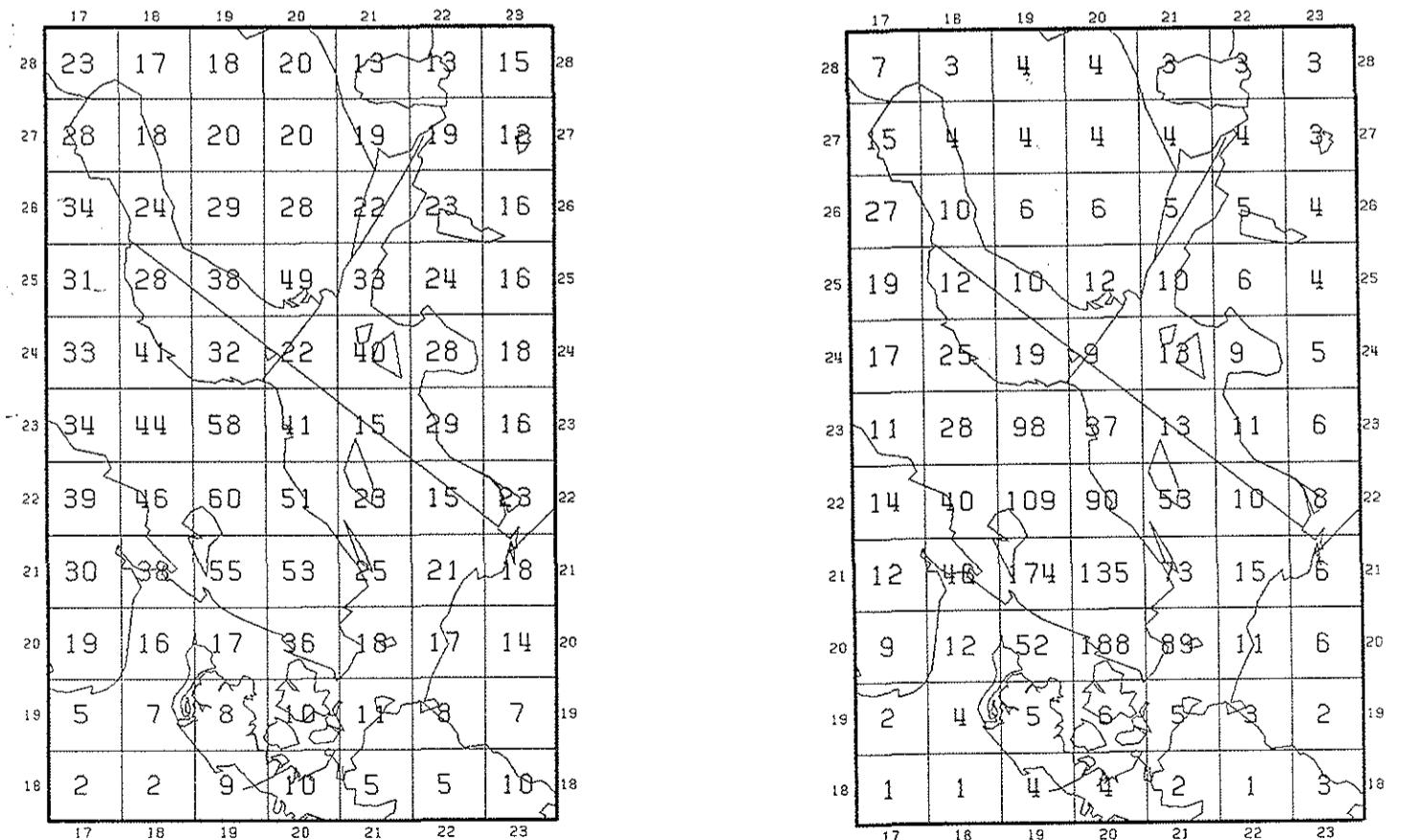


TOTAL DEP. OF OXIDIZED NITROGEN ( MG/M2 AS N )  
CONTRIBUTION FROM - POLAND - PL  
THE WHOLE YEAR - 1988, EMEP/MSC-W ACID MODEL

TOTAL DEP. OF REDUCED NITROGEN ( MG/M2 AS N )  
CONTRIBUTION FROM - POLAND - PL  
THE WHOLE YEAR - 1988, EMEP/MSC-W ACID MODEL

Figure B.6.

75

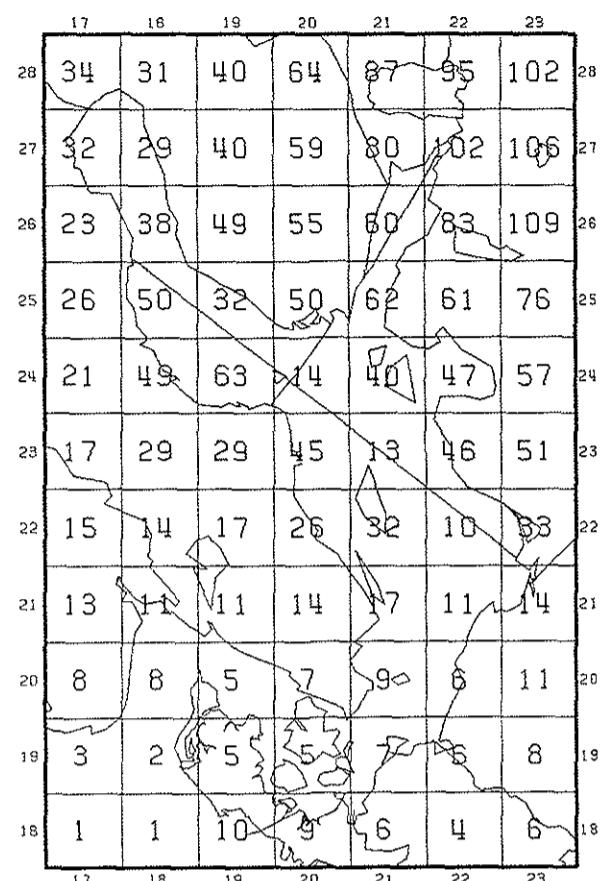


TOTAL DEP. OF OXIDIZED NITROGEN ( MG/M2 AS N )  
CONTRIBUTION FROM - SWEDEN - SE  
THE WHOLE YEAR - 1988, EMEP/MSC-W ACID MODEL

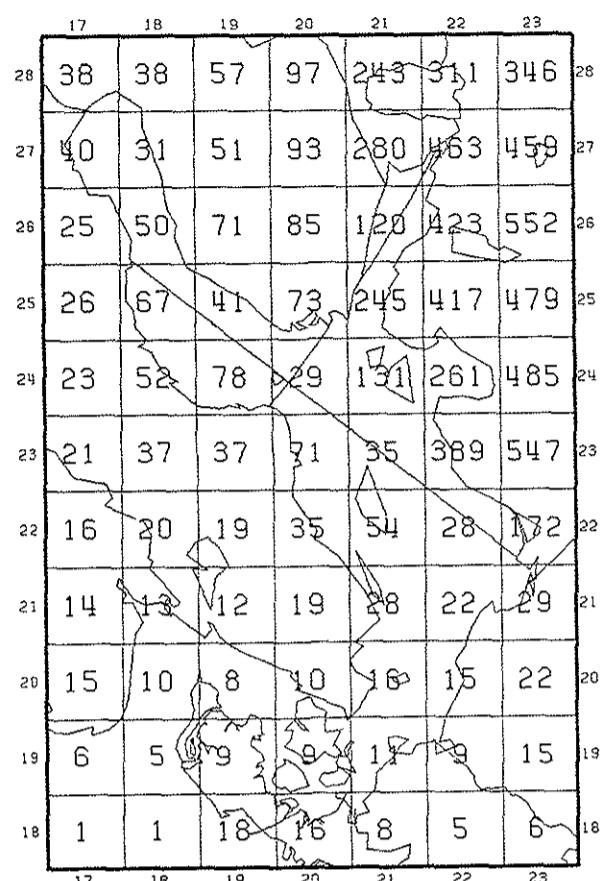
TOTAL DEP. OF REDUCED NITROGEN ( MG/M2 AS N )  
CONTRIBUTION FROM - SWEDEN - SE  
THE WHOLE YEAR - 1988, EMEP/MSC-W ACID MODEL

Figure B.7.

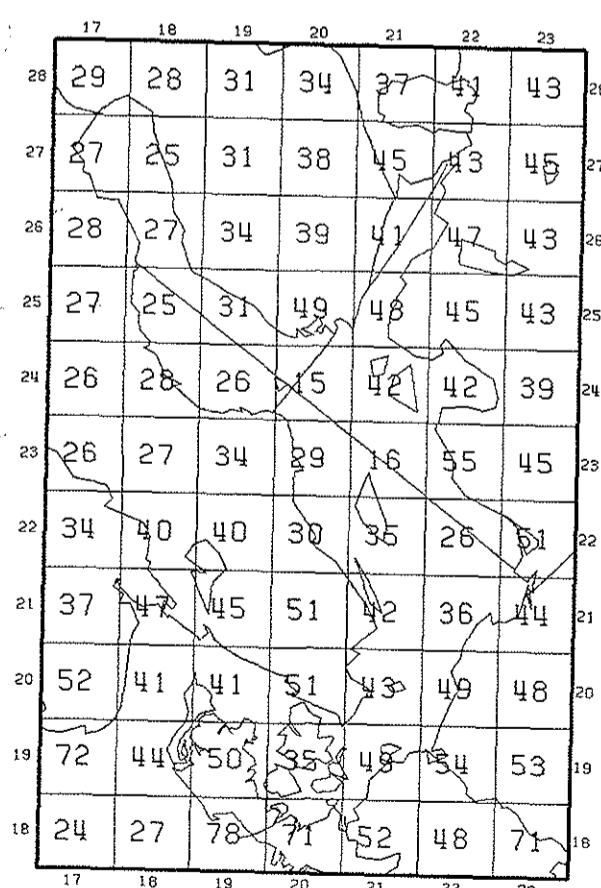
76



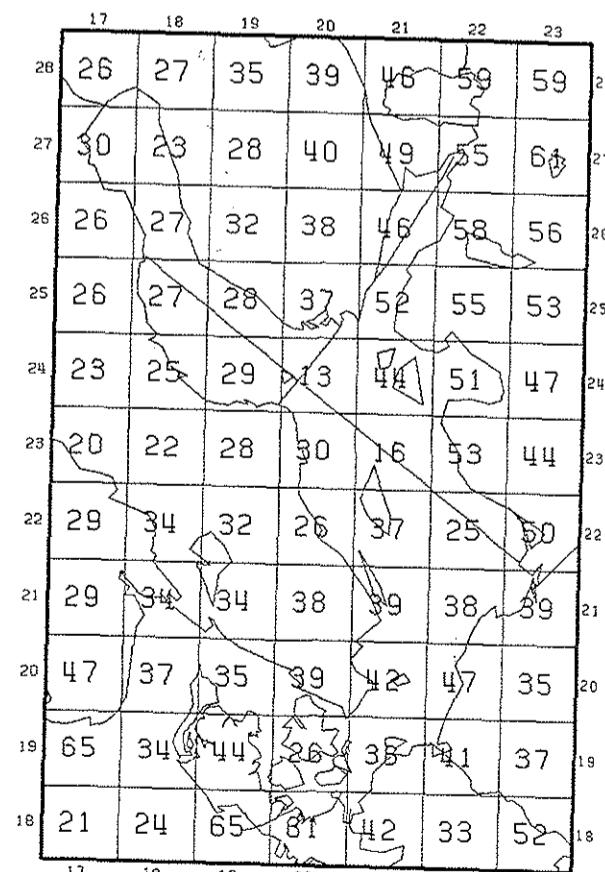
TOTAL DEP. OF OXIDIZED NITROGEN ( MG/M<sup>2</sup> AS N )  
CONTRIBUTION FROM - USSR (EUROPEAN) - SU  
THE WHOLE YEAR - 1988, EMEP/MSC-W ACID MODEL



TOTAL DEP. OF REDUCED NITROGEN ( MG/M<sup>2</sup> AS N )  
CONTRIBUTION FROM - USSR (EUROPEAN) - SU  
THE WHOLE YEAR - 1988, EMEP/MSC-W ACID MODEL



TOTAL DEP. OF OXIDIZED NITROGEN ( MG/M<sup>2</sup> AS N )  
INATTRIBUTABLE CONTRIBUTIONS - IND  
THE WHOLE YEAR - 1988, EMEP/MSC-W ACID MODEL



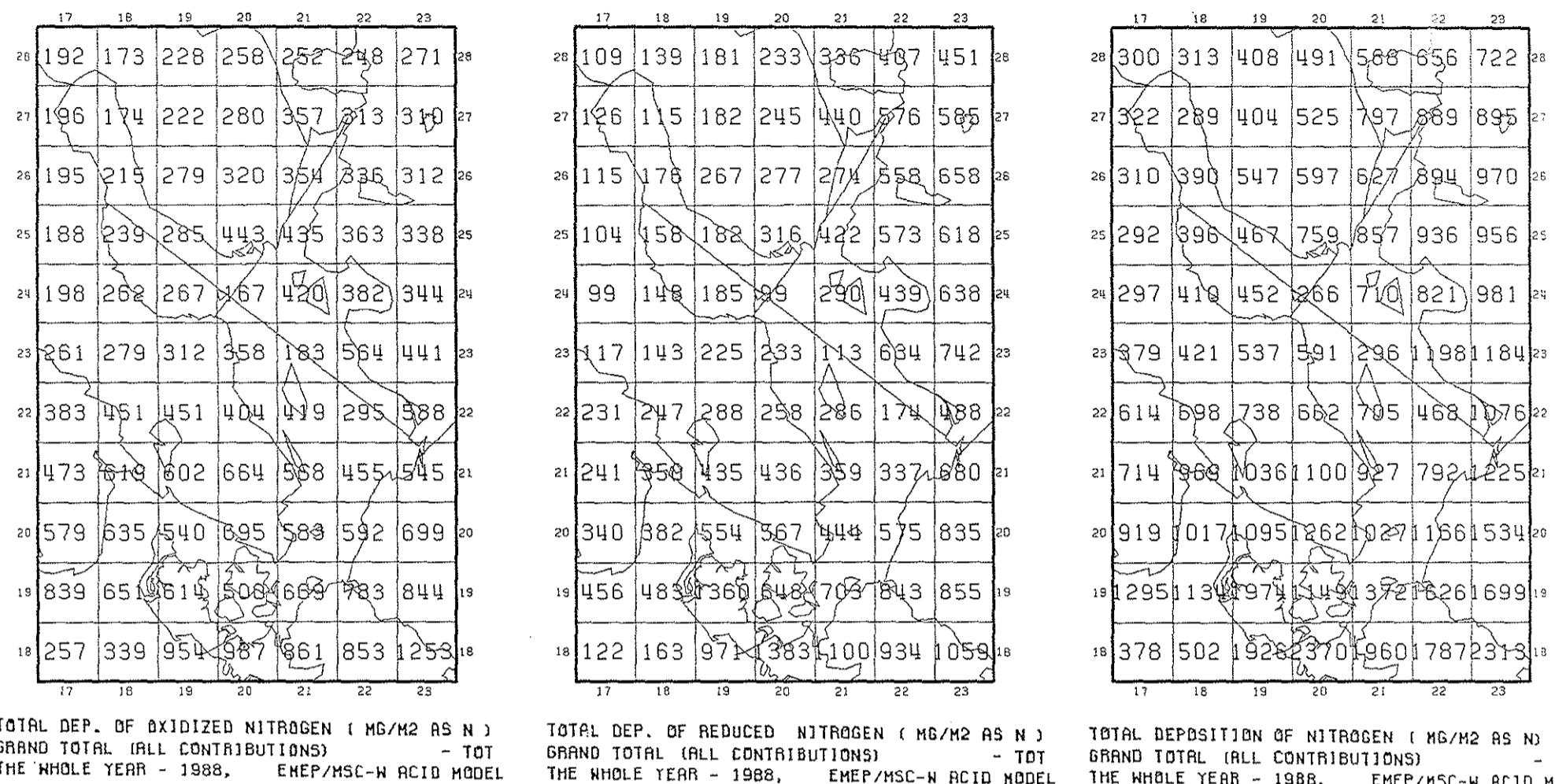
TOTAL DEP. OF REDUCED NITROGEN ( MG/M<sup>2</sup> AS N )  
INATTRIBUTABLE CONTRIBUTIONS - IND  
THE WHOLE YEAR - 1988, EMEP/MSC-W ACID MODEL

Figure B.8.

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Figure B.9.

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APPENDIX C:  
Nitrogen Compounds:  
Results on Concentrations, Fluxes, and Depositions

79

**C.1. Precipitation concentrations.**
**Table C.1.1. Annual mean concentrations of NO<sub>3</sub> in precipitation (mg N/l).**

Gulf of Bothnia	1986	1987	1988	1989	1990	1986-90
Hailuoto	0.42	0.41	0.65	0.44	0.43	0.47
Rahja	0.34	0.30		0.28	0.32	0.31
Rickleå	0.33	0.44	0.45	0.39	0.33	0.38
Sulva	0.70	0.44	0.32	0.32	0.49	0.45
Ylimarkku	0.50	0.57	0.52	0.52	0.45	0.51
Korppoo	0.55	0.50	0.67	0.63	0.47	0.56
Jomala	0.56	0.87	0.74	0.64	0.60	0.67
Basin average:	0.49	0.51	0.57	0.47	0.47	0.50
Gulf of Finland	1986	1987	1988	1989	1990	1986-90
Virolahti	0.60	0.59	0.49	0.47	0.44	0.52
Haapasaari	0.73	0.39	0.63	0.84	0.74	0.64
Vanhankylänmaa	0.86	0.48	0.74			0.69
Sipo	0.59	0.54	0.64	0.49	0.45	0.54
Lahemaa	0.25	0.31	0.30	0.30	0.30	0.30
Tvärminne	0.64	0.58	0.76	0.70	0.56	0.64
Basin average:	0.67	0.50	0.60	0.53	0.49	0.56
Baltic Proper, North	1986	1987	1988	1989	1990	1986-90
Utö	1.27	0.63	0.90	0.72	0.72	0.86
Aspvreten	0.49	0.42	0.52	0.61	0.44	0.49
Syrve	0.45	0.63	0.56	0.85	0.75	0.66
Hoburg	0.79	0.73	0.85	1.11	0.77	0.84
Rucava	0.68	0.51	0.51	0.61	0.61	0.59
Basin average:	0.73	0.57	0.64	0.76	0.67	0.67
Baltic Proper, South	1986	1987	1988	1989	1990	1986-90
Nida	0.59	0.97	1.04		0.72	0.77
Arup	0.69	0.53	0.63	0.78	0.66	0.65
Leba		0.73	0.71	0.50	0.47	0.60
Kap Arkona	0.83	1.62	0.83	0.76	0.68	0.95
Basin average:	0.72	0.92	0.73	0.68	0.63	0.73
Belt Sea and Kattegat	1986	1987	1988	1989	1990	1986-90
Rörvik	0.85	0.58	0.80	0.79	0.63	0.72
Vavihill	0.70	0.53	0.65	0.83	0.71	0.68
Keldsnor	0.71	0.81	0.87	0.68	0.63	0.74
Kiel Bight	1.54					1.54
Dänisch-Nienhof		0.65	0.82	0.86		0.65
Basin average:	0.76	0.62	0.77	0.80	0.66	0.72

**Table C.1.2. Annual mean concentrations of NH<sub>4</sub> in precipitation (mg N/l).**

Gulf of Bothnia	1986	1987	1988	1989	1990	1986-90
Hailuoto		0.68	0.50	0.68	0.38	0.44
Rahja		0.52	0.25		0.25	0.20
Rickleå		0.36	0.40	0.39	0.49	0.29
Sulva		0.70	0.41	0.31	0.68	0.69
Ylimarkku		0.89	1.02	0.71	0.92	0.96
Korppoo		0.73	0.52	0.83	0.65	0.44
Jomala		0.69	0.96	0.74	0.82	0.62
Basin average:	0.66	0.59	0.63	0.61	0.55	0.61
Gulf of Finland	1986	1987	1988	1989	1990	1986-90
Virolahti	0.80	0.71	0.51	0.66	0.45	0.62
Haapasaari	0.67	0.66	0.60	0.93	0.96	0.74
Vanhankylänmaa	0.88	0.65	0.73			0.75
Sipoo	0.77	0.59	0.58	0.51	0.34	0.56
Lahemaa	0.22	0.60	0.35	0.59	0.26	0.46
Tvärminne	0.59	0.77	0.56	0.72	0.43	0.60
Basin average:	0.74	0.67	0.56	0.65	0.45	0.62
Baltic Proper, North	1986	1987	1988	1989	1990	1986-90
Utö	0.63	0.46	0.67	0.81	0.60	0.64
Aspvreten	0.43	0.34	0.49	0.62	0.37	0.44
Syrve	0.46	0.57	0.60	0.60	0.47	0.54
Hoburg	0.87	0.79	1.49	1.21	1.84	1.28
Rucava	0.55	0.39	0.31	0.65	0.37	0.45
Basin average:	0.57	0.49	0.64	0.74	0.66	0.62
Baltic Proper, South	1986	1987	1988	1989	1990	1986-90
Nida	0.65	0.56	1.01		0.66	0.68
Arup	0.69	0.50	0.68	0.87	0.80	0.70
Leba		0.90	0.49	0.73	0.59	0.67
Kap Arkona	0.89	1.01	0.97	0.90	0.84	0.92
Basin average:	0.75	0.76	0.72	0.83	0.72	0.75
Belt Sea and Kattegat	1986	1987	1988	1989	1990	1986-90
Rörvik	0.82	0.63	0.71	0.68	0.64	0.69
Vavihill	0.85	0.62	0.65	1.14	1.16	0.87
Keldsnor	0.88	1.07	0.95	0.88	1.18	1.00
Kiel Bight	1.64					1.64
Dänisch-Nienhof		0.57	0.93	1.01		0.70
Basin average:	0.84	0.67	0.79	0.95	0.96	0.84

## C.2. Deposition Fluxes

Table C.2.1. Annual wet deposition fluxes  $F_w^x$  of  $\text{NO}_3$  ( $\text{kg N}/(\text{km}^2 \text{ yr})$ ).

Gulf of Bothnia	1986	1987	1988	1989	1990	1986-90
Hailuoto	207	214	278	222	163	217
Rahja	167	140		153	103	141
Rickleå	193	183	197	207	181	192
Sulva	376	231	194	157	274	246
Ylimarkku	308	284	337	304	252	297
Korppoo	424	377	455	335	353	389
Jomala	409	475	514	392	563	471
Basin average:	298	272	329	253	270	284
Gulf of Finland	1986	1987	1988	1989	1990	1986-90
Virolahti	397	382	355	334	304	354
Haapasaari	321	230	259	298	262	274
Vanhankylänmaa	489	283	410			394
Sipoo	457	316	409	329	341	370
Lahemaa		127	126	184	140	144
Tvärminne	423	423	459	388	488	436
Basin average:	417	293	336	307	307	332
Baltic Proper, North	1986	1987	1988	1989	1990	1986-90
Utö	750	300	453	383	446	466
Aspvreten	300	216	308	232	224	256
Syrve	241	305	432		707	421
Hoburg	343	271	350	392	405	352
Rucava	578	332	388		563	465
Basin average:	442	285	386	336	469	384
Baltic Proper, South	1986	1987	1988	1989	1990	1986-90
Nida	187	234	177		537	284
Arup	480	367	624	456	515	488
Leba		460	456	256	345	379
Kap Arkona	461	891	456	377	366	510
Basin average:	376	488	428	363	441	419
Belt Sea and Kattegat	1986	1987	1988	1989	1990	1986-90
Rörvik	562	426	666	466	537	532
Vavihill	521	454	593	635	587	558
Keldsnor	317	312	441	270	327	333
Kiel Bight	582					582
Dänisch-Nienhof		465	675	468		536
Basin average:	495	414	594	460	484	489

Table C.2.2. Annual wet deposition fluxes  $F_w^x$  of  $\text{NH}_4$  ( $\text{kg N}/(\text{km}^2 \text{ yr})$ ).

Gulf of Bothnia	1986	1987	1988	1989	1990	1986-90
Hailuoto		335	261	291	192	166
Rahja		256	117		137	65
Rickleå		210	166	171	261	159
Sulva		376	215	188	334	385
Ylimarkku		549	508	461	538	519
Korppoo		563	392	564	346	330
Jomala		504	524	514	503	581
Basin average:		399	312	365	330	318
Gulf of Finland	1986	1987	1988	1989	1990	1986-90
Virolahti		529	460	369	469	311
Haapasaari		295	389	247	330	340
Vanhankylänmaa		501	383	404		429
Sipoo		597	345	371	343	257
Lahemaa			245	147	362	122
Tvärminne		390	562	338	399	375
Basin average:		462	397	313	381	367
Baltic Proper, North	1986	1987	1988	1989	1990	1986-90
Utö		372	219	337	431	372
Aspvreten		263	175	291	236	188
Syrve		246	276	463		443
Hoburg		377	294	614	427	968
Rucava		467	254	236		342
Basin average:		345	244	388	365	463
Baltic Proper, South	1986	1987	1988	1989	1990	1986-90
Nida		206	135	172		492
Arup		480	346	673	509	624
Leba			568	315	374	422
Kap Arkona		494	555	533	446	453
Basin average:		394	401	423	443	500
Belt Sea and Kattegat	1986	1987	1988	1989	1990	1986-90
Rörvik			542	463	591	546
Vavihill		633	531	593	872	959
Keldsnor		392	412	481	350	612
Kiel Bight		620				620
Dänisch-Nienhof			408	765	549	574
Basin average:		547	453	608	543	705

### C.3. Depositions

**Table C.3.1.** Annual wet deposition  $D_{wb}^x$  of  $\text{NO}_3$  (kT N/yr).

Sub-basin	1986	1987	1988	1989	1990	1986-90
A <sub>1</sub> Gulf of Bothnia	34	31	38	29	31	33
A <sub>2</sub> Gulf of Finland	12	9	10	9	9	10
A <sub>3</sub> Baltic Proper, North	74	48	64	56	78	64
A <sub>4</sub> Baltic Proper, South	23	30	26	22	27	26
A <sub>5</sub> Belt Sea and Kattegat	21	18	25	20	21	21
A <sub>0</sub> Baltic Sea Total	164	135	164	136	166	153

**Table C.3.2.** Annual wet deposition  $D_{wb}^H$  of  $\text{NO}_3$  (kT N/yr).

Sub-basin	1986*	1987	1988	1989	1990	1986*-90
A <sub>1</sub> Gulf of Bothnia	36	36	41	34	37	37
A <sub>2</sub> Gulf of Finland	14	10	13	11	11	12
A <sub>3</sub> Baltic Proper, North	64	47	59	58	64	58
A <sub>4</sub> Baltic Proper, South	30	39	30	26	28	30
A <sub>5</sub> Belt Sea and Kattegat	24	18	25	23	24	23
A <sub>0</sub> Baltic Sea Total	168	150	167	152	165	160

\*) For 1986 the average values of  $P^H$  for 1987-1990 have been used.

**Table C.3.3.** Annual wet deposition  $D_{wb}^x$  of  $\text{NH}_4$  (kT N/yr).

Sub-basin	1986	1987	1988	1989	1990	1986-90
A <sub>1</sub> Gulf of Bothnia	46	36	42	38	37	40
A <sub>2</sub> Gulf of Finland	14	12	9	11	8	11
A <sub>3</sub> Baltic Proper, North	58	41	65	61	77	60
A <sub>4</sub> Baltic Proper, South	24	24	26	27	31	26
A <sub>5</sub> Belt Sea and Kattegat	23	19	26	23	30	24
A <sub>0</sub> Baltic Sea Total	165	132	168	160	183	161

**Table C.3.4.** Annual wet deposition  $D_{wb}^H$  of  $\text{NH}_4$  (kT N/yr).

Sub-basin	1986*	1987	1988	1989	1990	1986*-90
A <sub>1</sub> Gulf of Bothnia	48	41	45	44	43	44
A <sub>2</sub> Gulf of Finland	16	14	12	14	10	13
A <sub>3</sub> Baltic Proper, North	50	41	60	57	63	54
A <sub>4</sub> Baltic Proper, South	31	32	29	32	32	31
A <sub>5</sub> Belt Sea and Kattegat	27	20	25	27	35	27
A <sub>0</sub> Baltic Sea Total	172	147	171	174	184	170

\*) For 1986 the average values of  $P^H$  for 1987-1990 have been used.

**SUPPLEMENT****PRECIPITATION AND AIR CHEMISTRY AT HELCOM STATIONS  
FOR THE PERIOD 1986-1990****Monthly Statistics**

**PRECIPITATION AND AIR CHEMISTRY AT HELCOM STATIONS  
FOR THE PERIOD 1986-1990**

**1 INTRODUCTION**

This report presents data reported to HELCOM during the period 1986-1990. The data are presented as measured (monthly values) and as annual mean values from each station.

**2 THE DATA**

Data on precipitation and/or air quality are reported from 25 sites in 1986, from 27 sites in 1987 and from 25 sites in 1988, 1989 and 1990. Two of the Finnish sites (Hailuoto and Virolahti) have reported two sets of data, one from a bulk and one from a wet-only sampler.

The location of the measuring sites during this period are shown in Figure 1.

Most of the reported data are on macroconstituents in precipitation. Data on heavy metals in precipitation are few and reported from only 6-7 sites every year. Data on sulphur and/or nitrogen compounds in gases and aerosols are reported from 12 sites in 1986 and 1987, 13 sites in 1988, 11 sites in 1989 and 10 sites in 1990. The data coverage for each component, station and year are presented in tables in the Data Annexes.

The quality assurance for the reported data with respect to data checking and storage of HELCOM/EGAP analytical data at NILU, are based on the Quality Assurance Plan for EMEP (EMEP/CCC-Report 1/88), and a short summary is given in Annex 1.

### 3 MEAN VALUES

The arithmetic annual mean values of gases and components in aerosols and the precipitation weighted arithmetic annual mean concentrations together with the measured monthly values are presented in Annex 2-6 for 1986-90 respectively. The data are presented in tables covering one station and year showing the following components:

mm	- precipitation amount	(mm)
NO <sub>3</sub> N	- nitrate	(mg N/l)
NH <sub>4</sub> N	- ammonium	(mg N/l)
SO <sub>4</sub> S-C	- sulphate, sea salt corr.	(mg S/l)
Na	- sodium	(mg/l)
Mg	- magnesium	(mg/l)
Pb	- lead	(µg/l)
Cd	- cadmium	(µg/l)
Cu	- copper	(µg/l)
Zn	- zinc	(µg/l)
Cl	- chloride	(mg/l)
SO <sub>2</sub> S	- sulphur dioxide	(µg/m <sup>3</sup> )
A-SO <sub>4</sub> S	- sulphate	(µg/m <sup>3</sup> )
NO <sub>2</sub> N	- nitrogen dioxide	(µg/m <sup>3</sup> )
T-NO <sub>3</sub> N	- sum of nitric acid and nitrate	(µg N/m <sup>3</sup> )
T-NH <sub>4</sub> N	- sum of ammonia and ammonium	(µg N/m <sup>3</sup> )

The sulphate in precipitation is stored in the data base as reported i.e. total sulphate, and as corrected sulphate, i.e. total sulphate minus sulphate originating from sea salt particles. The concentration of sulphate from sea salt for one particular month has been estimated either by using sodium, the magnesium or the chloride concentration in that order of preference:

$$[\text{SO}_4^{--} - S_{\text{corr}}] = [\text{SO}_4^{--} - S_{\text{total}}] - \text{Fak} * [X]$$

when  $X = \text{Na}^+$        $\text{Fak} = 0.0837$  (Sverdrup et al., 1942)  
   "    $X = \text{Mg}^{++}$       "       $= 0.695$   
   "    $X = \text{Cl}^-$       "       $= 0.0466$

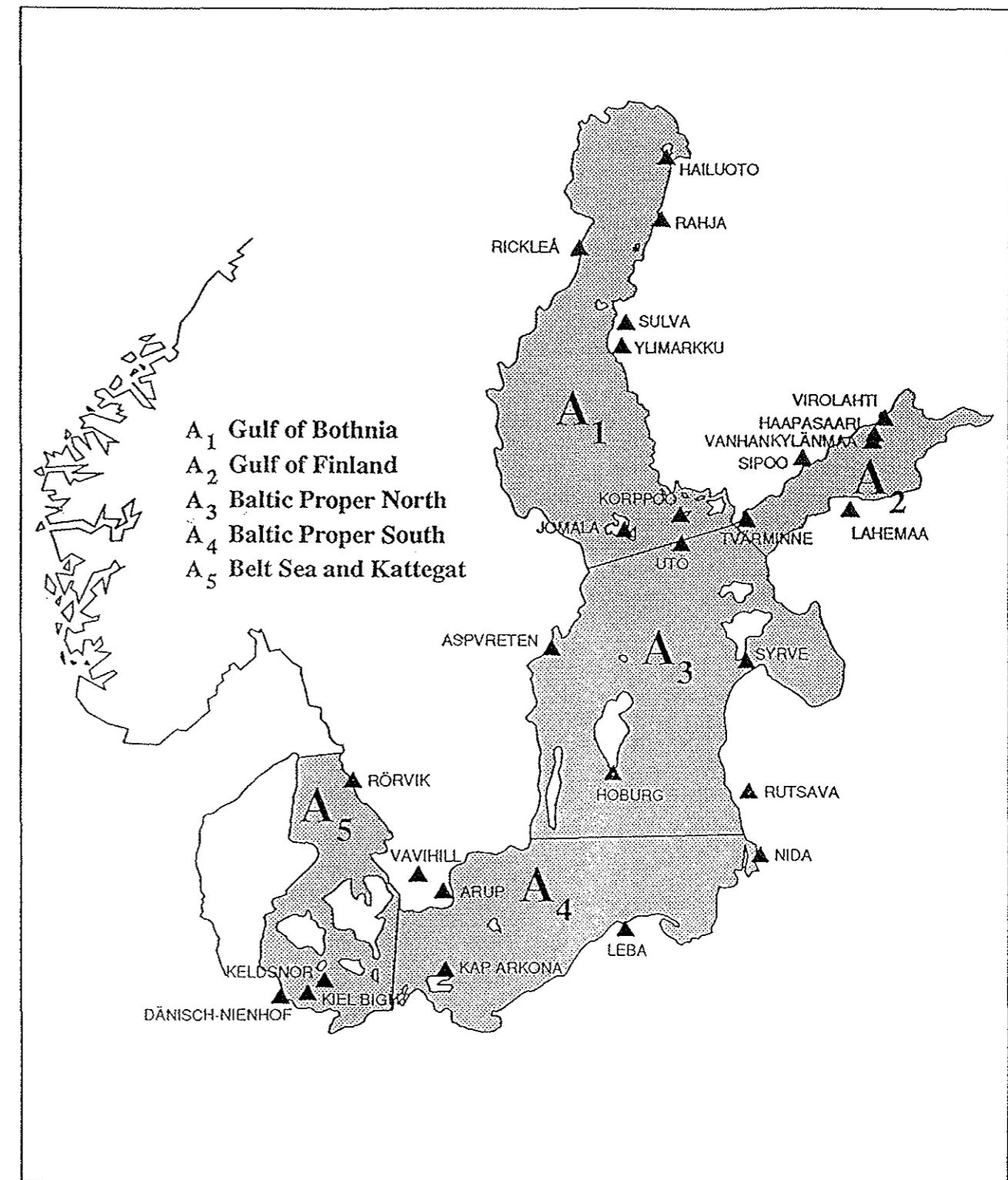


Figure 1: Location of stations which reported to HELCOM during the period 1986-90.

**4 REFERENCES**

Chemical Co-ordinating Centre (1988) J. Schaug. Quality Assurance Plan for EMEP. Lillestrøm, NILU (EMEP/CCC-Report 1/88).

Sverdrup, H.U., Johnson, M.W., Fleming, R.H. (1942) The Oceans, their Physics, Chemistry and General Biology. New York, Prentice Hall.

**ANNEX 1**

Quality assurance protocol HELCOM/EGAP data.  
A short description.

**QUALITY ASSURANCE PROTOCOL HELCOM/EGAP DATA**  
**A short description**

The quality assurance protocol used by NILU, for data checking of HELCOM/EGAP analytical data is based on the Quality Assurance Plan for EMEP (EMEP, CCC-Report 1/88).

A short summary of the quality assurance protocol is given below.

**DATA HANDLING**

The data handling includes data reporting, data control and data management.

Data reporting to NILU

The data reporting forms shall according to paragraph 2 in the agreement, be described by NILU. The filled-in data forms used by EGAP/HELCOM so far, can also be used in the future, but the participants should be encouraged to report their data on MS-DOS discettes. The required format will be given by NILU.

The full monthly data set shall be delivered to NILU not later than the first of April each year.

Quality control of the data

The quality control suggested below shall be carried out at the laboratory producing the data before the data are sent to NILU,

as well as at NILU when receiving the data. Any data which may be in error shall result in a new analysis of the sample when possible.

At NILU the data shall be checked after keypunching the data in the forms, or after having read the discette from the participant. Any data which may be questionable shall be returned to the participant without delay in order to have them compared with the journals and reanalysed if necessary and possible.

Statistical tests

The statistical tests compare new measurements with data already stored in the database. The tests are carried out in order to identify possible outliers and results which may be wrong. They can be based upon assumptions about the data distributions i.e. a lognormal distribution, or they can be based on comparisons with cumulative frequency distributions.

Gaseous, aerosol or precipitation components may be compared with all earlier data for each component making use of lognormal distributions. The data should then be split into data from different seasons or into winter and summer data. Data outside three or four times the standard deviations should be inspected manually by comparison with other components, and concentrations at neighbouring stations.

The distributions of the different types of data may deviate from a theoretical lognormal distribution. The deviation may be particularly notable in the low concentration part of the distribution where all concentrations less than the detection limit will have to be set equal to a small value. Since the tests are used only to identify measurements which should be inspected more closely, minor deviations from a theoretical distribution function can be accepted.

### Ion balance computation

If the precipitation programme includes measurements of all the main components in the precipitation, the sum of positive and negative ion concentrations expressed in microequivalents pr. litre shall then be zero. Alternatively, the ratio between the anion and cation concentrations expressed in microequivalents pr. litre shall be close to one.

The effect of minor components e.g. phosphates and organic acids, which are not included in the analysis, is usually negligible in "acid precipitation".

Assuming equilibrium between carbon dioxide in air and carbonic acid in precipitation, the bicarbonate concentration is negligible when the pH is below 5 and will only contribute 5  $\mu\text{e/l}$  at pH=6. Bicarbonate ions dissociate into carbonate ions, but this is negligible below pH=8 (at 25°C, EPA, 1985). However, precipitation samples sometimes seem to be supersaturated with carbon dioxide and will then contain more bicarbonate than expected.

During storage, soil dust, organic material etc. may be dissolved, or biological processes may occur under unfavorable conditions. Deviations in the ionic sum from zero may indicate this.

The ionic balance check should be carried out as soon as possible, while the chemical analysis can still be repeated. If a complete chemical analysis is performed, the ionic balance test is equally useful for aerosol samples.

### Conductivity computations

The conductivity of the precipitation samples should be measured, and compared with values calculated from the measured concentrations by adding the equivalent ionic conductivities.

The conductivity measurements should be carried out at a well defined temperature i.e. 25°C.

It should be noted, however, that at low pH values ( $\text{pH} \leq 4.0$ ) the conductivity of the solution will be dominated by the hydrogen ions. Errors in the concentrations of other ionic species will then not be easily detected.

The test should therefore be used together with the ionic balance test.

### Other methods for data check

Graphical plots and ratios between components which have a simple relationship, for instance sea salt components, should be utilized.

### Rejection of data

No data should be rejected automatically by use of computer programmes alone, manual inspection should be carried out before this step is taken.

Data carrying other types of information, as for instance contamination by insects, careless handling of samples etc., should only be accepted in the data base when the effect of the contamination is considered to be negligible.

**ANNEX 2**

Annual statistics on HELCOM/EGAP data 1986

DATA COVERAGE 1986		*	**	AIR														
		mm	mm	NO <sub>3</sub>	NH <sub>4</sub>	SO <sub>4</sub>	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO <sub>2</sub>	SO <sub>4</sub>	NO <sub>2</sub>	TNx	TNy
SF	VANHANKYLANMAA	11	BM	12	12	12	12	9	9	5	5	5	12	-	-	-	-	-
SF	HAILUOTO	12	BM	12	11	10	10	-	-	-	-	-	12	-	-	-	-	-
SF	HAILUOTO	12	WM	5	5	5	5	-	-	-	-	-	12	12	-	-	-	-
SF	VIROLAHTI	13	BD	12	12	12	12	-	-	-	-	-	8	-	-	-	-	-
SF	VIROLAHTI	13	BM	12	11	10	9	9	9	-	-	-	12	12	10	4	-	-
SF	UTØ	14	BD	12	12	12	12	11	8	7	8	7	-	-	-	-	-	-
SF	HAAPASAARI	15	WM	8	8	8	8	-	-	-	-	-	10	-	-	-	-	-
SF	TVÆRMINNE	16	BM	12	10	10	10	9	9	9	9	9	-	-	-	-	-	-
SF	JOMALA	17	BM	12	10	10	10	9	9	9	9	9	-	-	-	-	-	-
SF	RAJJA	18	BM	12	9	9	10	9	9	9	9	9	-	-	-	-	-	-
SF	YLIMARKKU	19	BM	12	8	10	9	8	8	8	8	8	-	-	-	-	-	-
SF	SIPOO	20	BM	12	10	10	10	10	10	10	10	10	-	-	-	-	-	-
SF	SULVA	21	BM	12	10	10	10	9	9	9	9	9	-	-	-	-	-	-
SF	KORPOO	22	BM	12	10	10	10	9	9	9	9	9	-	-	-	-	-	-
SE	ARUP	31	WM	12	12	12	12	12	12	12	12	12	-	-	-	-	-	-
SE	ASPVRETTEN	32	WM	12	12	12	12	12	12	12	12	12	-	-	-	-	-	-
SE	RICKLEÅ	33	BM	12	12	12	12	11	11	11	11	11	-	-	-	-	-	-
SE	VAVIHILL	34	WD	11	11	11	11	11	11	11	11	11	-	-	-	-	-	-
SE	RØRVIK	35	WD	11	11	11	11	11	11	11	11	11	-	-	-	-	-	-
SE	HOBURG	36	WD	12	12	12	12	12	12	12	12	12	-	-	-	-	-	-
SU	NIDA	41	BD	10	10	10	10	10	10	10	10	10	-	-	-	-	-	-
SU	SYRVE	42	BD	11	11	11	11	11	11	11	11	11	-	-	-	-	-	-
SU	RUTSABA	43	BD	12	12	12	12	12	12	12	12	12	-	-	-	-	-	-
SU	LAHEMAA	44	BD	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-
DD	KAPARKONA	61	WW	12	12	12	12	12	12	12	12	12	-	-	-	-	-	-
DE	KIEL BIGHT	71	WW	11	11	8	11	8	11	8	11	8	-	-	-	-	-	-
DK	KELDSNOR	81	WD	12	12	12	12	12	12	12	12	12	-	-	-	-	-	-

Precipitation and air data reported to HELCOM.

Number of monthly averages reported per station.

\*) Internal station nr.

\*\*) B - Bulk, W - Wet only

M - Monthly, W - Weekly, D - Daily

Country : FINLAND  
 Station : VANHANKYLANMAA  
 Year : 1986

Sampler type : BULK  
 Sampling period : MONTHLY

mm	NO <sub>3</sub> N	NH <sub>4</sub> N	SO <sub>4</sub> S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO <sub>2</sub> S	A-SO <sub>4</sub> S	NO <sub>2</sub> N	T-NO <sub>3</sub> N	T-NH <sub>4</sub> N	
JAN	29.0	1.00	.67	3.69	-	.30	5.90	.15	-	17.00	-	-	-	-	-	-
FEB	12.0	1.51	.55	2.93	-	.25	5.60	.13	-	23.00	-	-	-	-	-	-
MAR	24.0	1.07	.99	3.85	-	.21	6.40	.25	-	14.00	-	-	-	-	-	-
APR	44.0	.74	1.67	2.91	-	.13	4.80	.18	-	15.00	-	-	-	-	-	-
MAY	35.0	1.43	2.45	5.09	-	.30	8.30	.36	-	31.00	-	-	-	-	-	-
JUN	10.0	.52	.28	1.55	-	.22	.50	.16	-	16.00	-	-	-	-	-	-
JUL	44.0	.41	.25	1.61	-	.13	2.00	.09	-	13.00	-	-	-	-	-	-
AUG	108.0	.26	.56	.94	-	.08	1.50	.04	-	10.00	-	-	-	-	-	-
SEP	72.0	.47	.26	1.65	-	.65	1.60	.12	-	27.00	-	-	-	-	-	-
OCT	69.0	1.16	1.41	3.13	-	.24	8.20	.62	-	23.00	-	-	-	-	-	-
NOV	69.0	1.06	1.07	2.27	-	.18	10.80	.60	-	19.00	-	-	-	-	-	-
DEC	53.0	1.77	.47	1.48	-	.32	9.80	.78	-	60.00	-	-	-	-	-	-
YEAR	569.0	.86	.88	2.28	-	.25	5.44	.31	-	22.29	-	-	-	-	-	-

Country : FINLAND  
 Station : HAILUOTO  
 Year : 1986

Sampler type : BULK  
 Sampling period : MONTHLY

mm	NO <sub>3</sub> N	NH <sub>4</sub> N	SO <sub>4</sub> S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO <sub>2</sub> S	A-SO <sub>4</sub> S	NO <sub>2</sub> N	T-NO <sub>3</sub> N	T-NH <sub>4</sub> N	
JAN	8.1	.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEB	3.0	.50	.50	1.82	2.20	.40	-	-	-	-	.80	-	-	-	-	-
MAR	22.8	1.80	3.50	6.38	1.40	.20	-	-	-	-	.70	-	-	-	-	-
APR	20.1	-	-	-	-	-	-	-	-	-	.60	-	-	-	-	-
MAY	53.9	.50	1.70	2.30	-	-	-	-	-	-	1.00	-	-	-	-	-
JUN	25.1	.01	.70	.97	.30	.10	-	-	-	-	.40	-	-	-	-	-
JUL	44.4	.03	.05	1.35	.60	.20	-</td									

Country : FINLAND  
Station : VIROLAHTI  
Year : 1986

Sampler type : BULK  
Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	78.3	.80	.60	1.63	-	.10	-	-	-	-	1.10	13.00	3.00	-	-	-
FEB	9.0	.50	.10	.53	-	.10	-	-	-	-	.70	11.00	3.00	-	-	-
MAR	39.7	.80	.80	1.08	-	.60	-	-	-	-	.60	6.00	4.00	-	-	-
APR	54.1	.70	1.50	2.53	-	.10	-	-	-	-	<.10	3.00	2.00	-	-	-
MAY	34.2	.90	1.90	3.03	-	.10	-	-	-	-	<.10	3.00	1.00	-	-	-
JUN	13.8	.40	.50	.83	-	.10	-	-	-	-	<.10	2.00	1.00	-	-	-
JUL	40.5	.20	.40	.63	-	.10	-	-	-	-	.10	2.00	1.00	-	-	-
AUG	74.6	.50	1.00	2.43	-	.10	-	-	-	-	.10	2.00	1.00	-	-	-
SEP	94.2	.20	.30	.73	-	.10	-	-	-	-	.10	2.00	1.00	-	-	-
OCT	72.0	.70	.90	1.63	-	.10	-	-	-	-	.70	3.00	1.00	-	-	-
NOV	84.6	.80	1.00	2.86	-	.20	-	-	-	-	1.40	2.00	1.00	-	-	-
DEC	65.9	.60	.40	.73	-	.10	-	-	-	-	.90	10.00	2.00	-	-	-
YEAR	660.9	.60	.80	1.68	-	.14	-	-	-	-	.70	4.92	1.75	-	-	-

Country : FINLAND  
Station : VIROLAHTI  
Year : 1986

Sampler type : BULK  
Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	67.9	1.00	.40	2.07	.40	.20	-	-	-	-	.70	-	-	-	-	-
FEB	65.0	.10	.50	-	-	-	-	-	-	-	-	-	-	-	-	-
MAR	28.0	1.60	1.80	3.53	.80	.30	-	-	-	-	1.30	-	-	-	-	-
APR	53.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAY	33.9	.90	1.50	3.00	-	-	-	-	-	-	.50	-	-	-	-	-
JUN	10.6	.01	.10	2.19	2.50	.30	-	-	-	-	.50	-	-	-	-	-
JUL	34.8	.10	.40	.97	.40	.10	-	-	-	-	.50	-	-	-	-	-
AUG	92.2	.20	.60	1.57	.40	.10	-	-	-	-	.50	-	-	-	-	-
SEP	88.5	.20	.06	.84	.70	.10	-	-	-	-	1.30	-	-	-	-	-
OCT	80.6	.70	.80	2.24	3.10	1.00	-	-	-	-	1.50	-	-	-	-	-
NOV	98.0	1.00	1.40	2.62	.90	.20	-	-	-	-	4.00	-	-	-	-	-
DEC	66.7	.70	.60	1.47	1.50	.40	-	-	-	-	-	-	-	-	-	-
YEAR	719.5	.59	.72	1.92	1.11	.31	-	-	-	-	1.36	-	-	-	-	-

Country : FINLAND  
Station : UTO  
Year : 1986

Sampler type : BULK  
Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	59.1	1.50	1.30	1.56	-	.20	-	-	-	-	5.30	7.00	2.00	-	-	-
FEB	2.2	3.10	1.20	3.90	-	-	-	-	-	-	7.80	9.00	2.00	-	-	-
MAR	28.0	1.80	1.40	2.56	-	.20	-	-	-	-	4.40	4.00	3.00	-	-	-
APR	57.9	.70	.80	1.66	-	.20	-	-	-	-	.10	2.00	1.00	-	-	-
MAY	51.3	1.20	.80	1.83	-	.10	-	-	-	-	.10	3.00	1.00	-	-	-
JUN	21.5	.30	.90	.67	-	.90	-	-	-	-	1.20	3.00	1.00	-	-	-
JUL	31.0	.80	.60	1.64	-	.80	-	-	-	-	.20	2.00	-	-	-	-
AUG	99.7	2.90	.30	.93	-	.10	-	-	-	-	.70	2.00	.90	-	-	-
SEP	70.9	.30	.20	.52	-	.40	-	-	-	-	2.40	3.00	1.00	1.50	-	-
OCT	56.8	.60	.40	.93	-	.10	-	-	-	-	3.60	2.00	1.00	1.50	-	-
NOV	66.9	.90	.60	1.16	-	.20	-	-	-	-	8.80	7.00	2.00	1.50	-	-
DEC	45.1	1.50	.50	2.38	-	.60	-	-	-	-	-	-	-	-	-	-
YEAR	590.4	1.27	.63	1.35	-	.28	-	-	-	-	2.30	4.00	1.50	1.35	-	-

Country : FINLAND  
Station : HAAPASAARI  
Year : 1986

Sampler type : WET ONLY  
Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAR	24.0	.77	.64	1.72	-	.11	7.10	1.34	-	-	45.00	-	-	-	-	-
APR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAY	35.0	1.44	2.56	4.76	-	.20	9.90	.29	-	-	24.00	-	-	-	-	-
JUN	10.0	.46	.33	6.06	-	.35	-	.50	-	-	-	-	-	-	-	-
JUL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AUG	108.0	.22	.32	.76	-	.06	4.10	.03	-	-	11.00	-	-	-	-	-
SEP	72.0	.23	.14	.45	-	.07	5.70	.03	-	-	7.00	-	-	-	-	-
OCT	69.0	.65	.75	1.33	-											

Country : FINLAND  
 Station : RAHJA  
 Year : 1986

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N T-NO3N	T-NH4N
JAN	17.2	.50	.30	.45	.60	.10	-	-	-	-	1.00	-	-	-	-
FEB	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAR	25.0	1.30	1.50	2.84	1.90	.30	-	-	-	-	2.30	-	-	-	-
APR	31.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAY	53.0	.30	1.40	.90	-	-	-	-	-	-	.30	-	-	-	-
JUN	6.8	-	.10	1.41	1.10	.30	-	-	-	-	1.70	-	-	-	-
JUL	78.1	.30	.30	1.44	.70	.10	-	-	-	-	.90	-	-	-	-
AUG	98.8	.10	.20	.64	.70	.10	-	-	-	-	.80	-	-	-	-
SEP	58.4	.10	-	.47	.40	.20	-	-	-	-	.80	-	-	-	-
OCT	44.7	.40	.30	.85	.60	.30	-	-	-	-	1.00	-	-	-	-
NOV	58.1	.40	.30	.36	.50	.03	-	-	-	-	.50	-	-	-	-
DEC	17.7	1.00	.90	1.69	1.30	.10	-	-	-	-	2.00	-	-	-	-
YEAR	492.2	.34	.52	.93	.72	.14	-	-	-	-	.83	-	-	-	-

Country : FINLAND  
 Station : YLIMARKU  
 Year : 1986

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N T-NO3N	T-NH4N
JAN	29.1	.60	.70	.78	.20	.10	-	-	-	-	.30	-	-	-	-
FEB	8.0	-	-	-	-	-	-	-	-	-	.90	-	-	-	-
MAR	44.2	1.20	1.50	1.96	.50	.10	-	-	-	-	-	-	-	-	-
APR	39.1	-	-	-	-	-	-	-	-	-	.50	-	-	-	-
MAY	34.2	.90	1.60	2.60	-	-	-	-	-	-	2.00	-	-	-	-
JUN	6.1	-	.40	-	-	-	-	-	-	-	1.00	-	-	-	-
JUL	52.1	.30	1.10	1.95	.60	.10	-	-	-	-	.20	-	-	-	-
AUG	76.6	.30	.50	1.08	.20	.04	-	-	-	-	.60	-	-	-	-
SEP	93.6	.20	.70	.96	.50	.05	-	-	-	-	1.00	-	-	-	-
OCT	65.8	.60	.90	1.35	.60	.10	-	-	-	-	.60	-	-	-	-
NOV	114.2	.50	.50	.67	.40	.04	-	-	-	-	1.60	-	-	-	-
DEC	53.6	-	1.60	1.76	.50	.10	-	-	-	-	.74	-	-	-	-
YEAR	616.6	.50	.89	1.30	.44	.07	-	-	-	-	.74	-	-	-	-

Country : FINLAND  
 Station : SIPOO  
 Year : 1986

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N T-NO3N	T-NH4N
JAN	76.7	.80	.70	1.57	.40	.10	-	-	-	-	.70	-	-	-	-
FEB	6.5	-	-	-	2.10	.20	-	-	-	-	-	-	-	-	-
MAR	28.1	1.60	1.90	3.05	.60	.10	-	-	-	-	1.10	-	-	-	-
APR	41.2	-	-	-	-	-	-	-	-	-	.80	-	-	-	-
MAY	40.0	.90	1.70	3.00	-	-	-	-	-	-	.50	-	-	-	-
JUN	31.2	.20	.10	1.87	.30	.20	-	-	-	-	.30	-	-	-	-
JUL	82.3	.30	.10	.87	.30	.10	-	-	-	-	.40	-	-	-	-
AUG	140.7	.20	.20	.87	.30	.10	-	-	-	-	.90	-	-	-	-
SEP	74.9	.20	.10	.76	.50	.10	-	-	-	-	1.00	-	-	-	-
OCT	87.7	.70	1.30	1.35	.60	.20	-	-	-	-	1.60	-	-	-	-
NOV	108.2	1.00	1.80	2.22	.90	.10	-	-	-	-	1.30	-	-	-	-
DEC	57.6	.70	.50	1.02	.90	.10	-	-	-	-	-	-	-	-	-
YEAR	775.1	.59	.77	1.45	.54	.12	-	-	-	-	.85	-	-	-	-

Country : FINLAND

Station : SULVA

Year : 1986

Sampler type : BULK

Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N T-NO3N	T-NH4N
JAN	31.9	.90	.80	1.07	.40	.10	-	-	-	-	.60	-	-	-	-
FEB	5.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAR	26.8	5.00	4.20	3.13	3.20	1.90	-	-	-	-	7.20	-	-	-	-
APR	35.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAY	28.5	.60	.80	1.70	-	-	-	-	-	-	.40	-	-	-	-
JUN	29.2	.01	.20	2.37	.30	.30	-	-	-	-	.60	-	-	-	-
JUL	69.7	.20	.80	1.17	.40	.10	-	-	-	-	.50	-	-	-	-
AUG	73.5	.20	.40	.87	.30	.10	-	-	-	-	.30	-	-	-	-
SEP	82.6	.10	.04	.45	.60	.10	-	-	-	-	.90	-	-	-	-
OCT	47.1	.50	.20	1.34	.70	.60	-	-	-	-	1.50	-	-	-	-
NOV	67.0	.60	.40	.65	.60	.10	-	-	-	-	1.00	-	-	-	-
DEC	40.7	1.70	1.40	2.47	2.80	.70	-	-	-	-	6.00	-	-	-	-
YEAR	537.3	.70	.70	1.26	.84	.32	-	-	-	-	1.52	-	-	-	-

Country : SWEDEN		Station : ASPVRETTEN		Sampler type : WET ONLY		Sampling period : MONTHLY											
		mm	N03N	NH4N	S04S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	S02S	A-S04S	N02N	T-N03N	T-NH4N
JAN	26.0	.86	.48	1.23	.53	.07	6.99	.16	-	19.60	.98	3.35	1.05	-	.60	1.06	
FEB	17.0	.79	.51	1.15	.27	.06	6.80	.18	-	25.30	.47	3.61	.92	-	.46	.89	
MAR	34.0	.74	.88	1.56	.39	.06	6.13	.13	-	14.30	.70	2.67	2.07	1.24	1.19	2.94	
APR	58.0	.37	.37	.93	.06	.02	5.55	.07	-	6.20	.19	.92	.70	1.09	.43	1.11	
MAY	62.0	.70	.74	1.19	.14	.03	6.36	.09	-	11.30	.30	2.04	1.97	.73	.62	1.30	
JUN	43.0	.35	.57	1.26	.03	.04	6.99	.07	-	11.30	.16	2.36	2.18	.63	.39	.99	
JUL	72.0	.37	.42	1.17	.06	.02	-	-	-	-	.17	.71	.76	.59	.29	.94	
AUG	67.0	.14	.05	.41	.13	.02	3.01	.04	-	4.40	.28	.42	.59	.31	.27	.78	
SEP	47.0	.20	.09	.41	.32	.04	.83	.03	-	5.50	.65	.28	.20	.27	.11	.39	
OCT	24.0	1.03	.68	1.44	.65	.10	3.88	.19	-	21.00	1.27	1.83	1.13	-	-	-	
NOV	59.0	.73	.45	.84	.36	.05	5.46	.17	-	12.30	.74	1.07	.61	.79	.18	.71	
DEC	103.0	.46	.38	.88	.40	.06	2.23	.12	-	7.70	.86	2.18	.92	1.87	.39	.92	
YEAR	612.0	.49	.43	.97	.25	.04	4.46	.10	-	10.27	.52	1.79	1.09	.84	.45	1.09	

Country : SWEDEN				Sampler type : BULK												
Station : RICKLEÅ				Sampling period : MONTHLY												
	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	41.0	.63	.37	1.08	.11	.03	-	-	-	-	.20	-	-	-	-	-
FEB	3.0	.27	.11	.82	-	-	-	-	-	-	.88	-	-	-	-	-
MAR	60.0	.62	.76	1.32	.24	.04	-	-	-	-	.49	-	-	-	-	-
APR	26.0	.40	.90	1.34	.13	.07	-	-	-	-	.18	-	-	-	-	-
MAY	52.0	.34	.53	1.02	.13	.03	-	-	-	-	.20	-	-	-	-	-
JUN	11.0	.03	.39	1.26	.08	.08	-	-	-	-	.20	-	-	-	-	-
JUL	49.0	.30	.24	1.29	.19	.05	-	-	-	-	.33	-	-	-	-	-
AUG	136.0	.18	.34	.92	.16	.03	-	-	-	-	.30	-	-	-	-	-
SEP	77.0	.07	.05	.36	.42	.05	-	-	-	-	.84	-	-	-	-	-
OCT	73.0	.44	.32	.89	.38	.05	-	-	-	-	.75	-	-	-	-	-
NOV	34.0	.42	.23	.59	.25	.03	-	-	-	-	.51	-	-	-	-	-
DEC	22.0	.33	.12	.66	.80	.11	-	-	-	-	1.50	-	-	-	-	-
YEAR	584.0	.33	.36	.93	.25	.04	-	-	-	-	.49	-	-	-	-	-

Country : SWEDEN				Station : VAVIHILL				Sampler type : WET ONLY				Sampling period : DAILY				
	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	67.0	.61	.52	.74	1.95	.23	-	-	-	-	4.00	7.70	1.49	2.30	-	-
FEB	-	-	-	-	-	-	-	-	-	-	-	5.30	1.09	1.10	.60	.61
MAR	54.0	1.22	2.84	2.17	.97	.14	-	-	-	-	1.60	8.70	2.53	2.30	2.52	2.48
APR	32.1	.97	1.15	2.23	.31	.11	-	-	-	-	1.10	3.40	1.67	.90	1.51	2.44
MAY	45.6	1.19	1.08	2.92	.52	.24	-	-	-	-	1.30	2.60	.90	1.00	1.09	2.49
JUN	17.9	.62	1.18	2.68	.21	.07	-	-	-	-	.50	2.00	.78	.70	.54	2.22
JUL	96.8	.53	.56	1.63	.58	.09	-	-	-	-	1.40	1.70	1.01	.80	.77	2.56
AUG	71.6	.58	.58	1.45	.21	.04	-	-	-	-	.70	1.30	.92	.80	.65	1.85
SEP	81.7	.34	.44	.90	1.13	.14	-	-	-	-	2.20	1.30	.58	1.20	.36	1.01
OCT	95.4	.63	.70	.96	.47	.06	-	-	-	-	.90	3.80	-	2.30	1.35	2.64
NOV	90.2	.76	.73	.84	.84	.08	-	-	-	-	1.30	3.70	-	3.10	1.19	2.14
DEC	92.1	.76	.76	1.01	1.43	.17	-	-	-	-	2.30	7.20	-	2.30	.75	1.70
YEAR	744.4	.70	.85	1.36	.85	.12	-	-	-	-	1.66	4.06	1.22	1.57	1.03	2.01

Country : SWEDEN		Sampler type : WET ONLY															
Station : RORVIK		Sampling period : DAILY															
	Year : 1986	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN		48.9	.63	.43	.57	5.92	.69	-	-	-	-	8.50	6.80	1.49	2.70	.60	.98
FEB		-	-	-	-	-	-	-	-	-	-	-	5.70	1.18	2.10	.61	1.19
MAR		79.6	1.07	1.07	1.39	.81	.13	-	-	-	-	2.00	6.10	2.72	2.00	2.12	2.46
APR		28.0	1.24	.89	2.24	.44	.09	-	-	-	-	1.30	2.90	1.14	1.40	.90	1.90
MAY		82.3	1.03	1.17	2.29	.96	.15	-	-	-	-	1.80	2.20	1.40	1.30	1.30	2.59
JUN		9.7	1.07	1.31	3.74	1.09	.19	-	-	-	-	1.40	2.30	2.18	.90	.72	2.12
JUL		39.8	1.42	1.58	4.01	.88	.20	-	-	-	-	2.70	2.10	1.85	.80	.73	2.03
AUG		98.5	.70	.74	1.55	2.06	.28	-	-	-	-	4.50	1.10	.78	.80	.55	1.35
SEP		34.7	.36	.03	.54	3.84	.46	-	-	-	-	7.80	.90	.45	1.30	.33	.72
OCT		85.2	.58	.75	.97	2.46	.31	-	-	-	-	5.70	3.60	-	2.10	1.19	1.94
NOV		94.1	.84	.73	.83	2.25	.36	-	-	-	-	5.30	3.00	-	2.20	.94	1.51
DEC		60.0	.78	.58	.89	5.22	.47	-	-	-	-	8.40	5.70	-	2.30	.59	1.40
YEAR		660.8	.85	.82	1.47	2.36	.30	-	-	-	-	4.67	3.53	1.47	1.66	.88	1.68

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	35.3	1.14	.60	1.14	1.41	.16	-	-	-	-	2.30	4.90	.75	1.20	-	-
FEB	3.8	2.56	1.50	3.07	1.22	.20	-	-	-	-	1.50	5.70	1.12	.60	-	-
MAR	25.9	1.48	1.53	2.43	2.65	.35	-	-	-	-	4.70	2.90	1.50	1.20	-	-
APR	45.7	.43	.56	2.01	.17	.03	-	-	-	-	.40	1.30	.83	.70	-	-
MAY	39.6	1.40	1.67	4.48	.28	.13	-	-	-	-	.80	1.30	.46	.60	-	-
JUN	13.3	.97	3.25	2.94	.76	.26	-	-	-	-	2.50	1.10	.44	.60	-	-
JUL	50.5	.39	.69	.99	.48	.08	-	-	-	-	1.40	.80	.65	.50	-	-
AUG	70.1	.41	.93	1.54	.37	.11	-	-	-	-	1.40	.70	.54	.50	-	-
SEP	22.4	.35	.38	.72	1.63	.20	-	-	-	-	3.50	.40	.26	.60	-	-
OCT	43.1	.52	.38	1.07	1.09	.15	-	-	-	-	2.00	1.80	-	1.60	-	-
NOV	43.9	1.05	.70	1.07	1.33	.13	-	-	-	-	1.50	2.20	-	2.70	-	-
DEC	40.4	1.02	.53	1.17	2.02	.20	-	-	-	-	2.90	5.30	-	2.70	-	-
YEAR	433.9	.79	.87	1.70	.98	.14	-	-	-	-	1.86	2.37	.73	1.12	-	-

Country : USSR				Sampler type : BULK				Sampling period : DAILY								
	mm	N03N	NH4N	S04S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	S02S	A-S04S	N02N	T-N03N	T-NH4N
JAN	9.2	1.03	.53	.74	1.69	-	-	-	-	-	-	1.71	-	-	-	-
FEB	6.1	.76	.06	.38	.61	-	-	-	-	-	-	5.19	-	.12	-	-
MAR	27.5	1.60	1.46	2.08	1.82	-	-	-	-	-	-	2.83	-	.11	-	-
APR	2.1	1.08	2.50	3.38	2.00	-	-	-	-	-	-	.50	-	.05	-	-
MAY	8.3	1.15	.84	1.53	1.76	-	-	-	-	-	-	.16	-	.18	-	-
JUN	44.8	.25	1.15	1.30	1.47	-	-	-	-	-	-	.05	-	.12	-	-
JUL	-	-	-	-	-	-	-	-	-	-	-	<.02	-	.08	-	-
AUG	-64.7	.84	.80	1.04	3.33	-	-	-	-	-	-	.26	7.84	.10	.94	1.31
SEP	91.5	.21	.05	.17	5.64	-	-	-	-	-	-	-	4.87	-	.60	1.36
OCT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NOV	36.7	.73	.52	1.78	7.20	-	-	-	-	-	-	.53	2.67	.16	.53	2.99
DEC	26.6	.18	.81	1.27	2.20	-	-	-	-	-	-	2.80	5.67	.25	1.07	5.01
YEAR	317.5	.59	.65	1.03	3.81	-	-	-	-	-	-	1.56	5.26	.13	.78	2.67

Country : USSR  
Station : SYRVE  
Year : 1986

Sampler type : BULK  
Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N	T-NH4N
JAN	39.3	.75	.51	.44	1.65	-	-	-	-	-	<.02	-	-	-
FEB	-	-	-	-	-	-	-	-	-	-	<.02	-	2.20	-
MAR	25.0	1.00	.96	1.13	1.23	-	-	-	-	-	<.02	-	3.83	-
APR	49.1	.53	.76	.70	.37	-	-	-	-	-	<.02	-	2.71	-
MAY	35.0	.67	.73	1.65	.92	-	-	-	-	-	<.02	-	1.81	-
JUN	26.1	.38	1.07	1.25	.78	-	-	-	-	-	<.02	-	1.26	-
JUL	70.9	.41	.79	<.02	2.17	-	-	-	-	-	<.02	-	.84	-
AUG	55.1	.28	.29	.80	.69	-	-	-	-	-	.17	1.44	.31	.16
SEP	72.4	.24	.12	.25	2.03	-	-	-	-	-	<.02	.95	.12	.12
OCT	56.4	.21	.06	.37	1.27	-	-	-	-	-	<.02	.23	1.20	.13
NOV	63.4	.53	.15	.68	1.73	-	-	-	-	-	<.02	.41	1.40	.13
DEC	42.5	.50	.37	.09	2.01	-	-	-	-	-	.10	.61	1.50	.10
YEAR	535.2	.45	.46	.65	1.44	-	-	-	-	-	.13	.73	1.56	.13
													.39	

Country : USSR  
Station : RUTSAVA  
Year : 1986

Sampler type : BULK  
Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N	T-NH4N
JAN	73.0	1.09	.61	1.02	1.29	-	-	-	-	-	-	-	-	-
FEB	2.4	1.35	.70	2.30	1.83	-	-	-	-	-	2.87	-	2.94	-
MAR	47.9	1.32	1.15	1.73	.58	-	-	-	-	-	1.01	-	1.11	-
APR	41.6	.58	1.09	1.34	.28	-	-	-	-	-	.50	-	1.82	-
MAY	41.1	.67	.40	1.18	.29	-	-	-	-	-	.42	-	2.27	-
JUN	64.7	.54	1.00	1.43	.12	-	-	-	-	-	.29	-	1.97	-
JUL	37.3	.62	.56	1.64	.78	-	-	-	-	-	.43	-	1.05	-
AUG	177.5	.29	.30	.54	.33	-	-	-	-	-	.14	.68	.49	.27
SEP	146.6	.44	.20	.37	1.08	-	-	-	-	-	.45	1.78	.16	.76
OCT	72.5	.81	.31	.68	.70	-	-	-	-	-	.63	1.29	2.00	1.03
NOV	119.3	1.00	.81	.94	1.31	-	-	-	-	-	.63	1.29	2.00	1.03
DEC	26.0	1.08	.55	.92	3.07	-	-	-	-	-	2.40	1.99	2.70	.62
YEAR	849.9	.68	.55	.89	.81	-	-	-	-	-	.91	1.43	1.65	.67
													1.91	

Country : USSR  
Station : LAHEMAA  
Year : 1986

Sampler type : BULK  
Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N	T-NH4N
JAN	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEB	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-
APR	-	-	-	-	-	-	-	-	-	-	1.71	-	.67	-
MAY	10.5	.36	.48	1.22	.20	-	-	-	-	-	.65	-	.37	-
JUN	43.4	.11	.06	1.00	.20	-	-	-	-	-	.48	-	2.22	-
JUL	103.1	.12	.10	.56	.32	-	-	-	-	-	.15	.71	.19	.59
AUG	101.3	.14	.16	.71	.06	-	-	-	-	-	.16	.54	.33	.22
SEP	37.1	.18	.10	.32	.29	-	-	-	-	-	.30	.85	.40	.14
OCT	36.6	.70	.27	.49	.14	-	-	-	-	-	.30	.52	.60	.10
NOV	20.0	.59	.90	.84	.25	-	-	-	-	-	.85	1.11	1.26	.18
DEC	42.8	.44	.52	1.14	.63	-	-	-	-	-	.58	.75	.75	.45
YEAR	394.8	.25	.22	.71	.25	-	-	-	-	-	.58	.75	.75	.25

Country : DDR  
Station : KAP ARKONA  
Year : 1986

Sampler type : WET ONLY  
Sampling period : WEEKLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N	T-NH4N
JAN	66.1	.70	.50	1.59	1.30	.20	-	-	-	-	2.60	7.20	1.60	-
FEB	17.5	1.60	.80	3.88	5.00	.90	-	-	-	-	10.10	1.40	-	-
MAR	31.5	1.30	2.10	3.53	.80	.20	-	-	-	-	1.50	5.00	3.50	-
APR	37.3	1.20	1.80	3.03	.80	.20	-	-	-	-	1.60	3.20	2.60	-
MAY	48.9	1.10	1.30	3.26	.50	.20	-	-	-	-	1.40	2.10	1.60	-
JUN	31.5	.60	.80	2.66	.50	.10	-	-	-	-	.70	1.50	2.30	-
JUL	83.7	.50	.80	1.57	.40	.10	-	-	-	-	.80	1.40	2.30	-
AUG	40.0	1.70	1.30	5.59	1.30	.40	-	-	-	-	3.10	2.10	1.50	-
SEP	48.8	.40	.30	1.01	1.10	2.60	-	-	-	-	2.10	1.60	1.00	-
OCT	74.6	.60	.60	2.47	1.60	.30	-	-	-	-	3.20	7.80	3.10	-
NOV	36.1	.70	.80	2.42	1.00	.20	-	-	-	-	1.70	7.20	3.00	-
DEC	39.5	.70	.50	2.23	2.00	.40	-	-	-	-	4.40	7.70	2.90	-
YEAR</														

**ANNEX 3**

Annual statistics on HELCOM/EGAP data 1987



Country : FINLAND  
 Station : VIROLAHTI  
 Year : 1987

Sampler type : BULK  
 Sampling period : DAILY

	mm	N03N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	N02N	T-N03N	T-NH4N
JAN	30.2	.30	.30	.50	-	<.10	-	-	-	-	.30	9.50	1.50	-	-	-
FEB	49.4	.70	.60	1.73	-	.10	-	-	-	-	.50	6.50	1.90	-	-	-
MAR	26.9	1.10	1.20	3.23	-	.10	-	-	-	-	.70	9.00	4.20	-	-	-
APR	6.1	1.10	.90	2.03	-	.10	-	-	-	-	.60	1.90	1.60	-	-	-
MAY	38.0	.80	1.50	2.73	-	.10	-	-	-	-	.20	1.90	1.60	-	-	-
JUN	71.4	1.40	.90	1.43	-	.10	-	-	-	-	.30	1.70	1.00	-	-	-
JUL	59.8	.20	.40	.83	-	.10	-	-	-	-	.20	1.60	1.10	-	-	-
AUG	107.1	.20	.70	1.00	-	<.10	-	-	-	-	.50	1.00	.60	-	-	-
SEP	116.0	.30	.40	.93	-	.10	-	-	-	-	.80	3.00	2.10	-	-	-
OCT	34.7	1.00	1.40	2.76	-	.20	-	-	-	-	.40	5.00	1.60	-	-	-
NOV	73.2	.70	.80	1.33	-	.10	-	-	-	-	.60	3.00	1.00	-	-	-
DEC	35.0	.60	.30	.90	-	<.10	-	-	-	-	.41	3.98	1.67	-	-	-
YEAR	647.8	.59	.71	1.38	-	.11	-	-	-	-	.41	3.98	1.67	-	-	-

Country : FINLAND  
 Station : VIROLAHTI  
 Year : 1987

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	N03N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	N02N	T-N03N	T-NH4N
JAN	20.7	.74	-	1.38	.54	.11	-	-	-	-	1.00	-	-	-	-	-
FEB	48.7	1.07	.86	2.82	.60	.24	-	-	-	-	1.10	-	-	-	-	-
MAR	31.5	1.86	2.13	5.10	.84	.29	-	-	-	-	1.30	-	-	-	-	-
APR	8.0	1.55	-	.47	-	-	-	-	-	-	.80	-	-	-	-	-
MAY	53.9	.86	1.70	2.85	.23	.18	-	-	-	-	.40	-	-	-	-	-
JUN	95.3	.49	1.60	2.85	.23	.18	-	-	-	-	.30	-	-	-	-	-
JUL	55.7	.20	.24	1.44	.37	.10	-	-	-	-	.40	-	-	-	-	-
AUG	150.1	.28	.58	1.45	.23	.08	-	-	-	-	.20	-	-	-	-	-
SEP	119.8	.25	.13	1.10	.36	.06	-	-	-	-	.40	-	-	-	-	-
OCT	58.1	1.05	1.20	3.83	.49	.30	-	-	-	-	1.20	-	-	-	-	-
NOV	66.7	.97	1.50	2.16	.49	.10	-	-	-	-	.70	-	-	-	-	-
DEC	53.8	.79	.77	1.73	.51	.22	-	-	-	-	.80	-	-	-	-	-
YEAR	762.3	.63	.93	2.16	.38	.15	-	-	-	-	.57	-	-	-	-	-

Country : FINLAND  
 Station : UTO  
 Year : 1987

Sampler type : BULK  
 Sampling period : DAILY

	mm	N03N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	N02N	T-N03N	T-NH4N
JAN	21.9	.40	.10	1.00	-	<.10	-	-	-	-	14.70	-	-	-	-	-
FEB	25.6	1.50	.40	1.49	-	.30	-	-	-	-	4.20	1.20	4.40	-	-	-
MAR	15.6	2.30	1.20	2.03	-	.10	-	-	-	-	2.10	11.30	3.50	-	-	-
APR	1.6	1.80	.30	2.48	-	.60	-	-	-	-	4.90	3.80	1.80	-	-	-
MAY	40.8	.50	.50	1.13	-	.10	-	-	-	-	1.50	3.30	1.20	-	-	-
JUN	57.1	.40	.50	1.13	-	.10	-	-	-	-	1.50	2.10	1.50	-	-	-
JUL	31.6	.30	.20	.63	-	.10	-	-	-	-	1.40	2.00	1.00	-	-	-
AUG	50.0	.30	.20	.56	-	.20	-	-	-	-	2.80	1.60	1.00	-	-	-
SEP	80.7	.40	.40	.86	-	.20	-	-	-	-	3.60	1.30	.60	-	-	-
OCT	50.2	.60	.60	1.13	-	.10	-	-	-	-	1.50	3.00	1.80	-	-	-
NOV	69.2	.90	.70	1.16	-	.20	-	-	-	-	2.40	4.00	1.00	-	-	-
DEC	32.1	.70	.30	.89	-	.30	-	-	-	-	4.60	3.00	.60	-	-	-
YEAR	476.4	.63	.46	1.03	-	.17	-	-	-	-	3.11	3.33	1.67	-	-	-

Country : FINLAND  
 Station : HAAPASAARI  
 Year : 1987

Sampler type : WET ONLY  
 Sampling period : MONTHLY

	mm	N03N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	N02N	T-N03N	T-NH4N
JAN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
APR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAY	34.0	.77	1.94	2.67	-	.18	2.50	.20	-	-	16.00	-	-	-	-	-
JUN	77.0	.49	.63	2.21	-	.13	5.80	.15	-	-	16.00	-	-	-	-	-
JUL	52.0	.29	.41	1.03	-	.10	3.00	.15	-	-	15.00	-	-	-	-	-
AUG	129.0	.27	.59	1.23	-	.10	4.00	.16	-	-	24.00	-	-	-	-	-
SEP	101.0	.39	.47	1.04	-	.09	5.60	.12	-	-	8.00	-	-	-	-	-
OCT																

Country : FINLAND  
Station : RAJUA  
Year : 1987

Sampler type : BULK  
Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	11.9	.37	.27	.75	2.65	.31	-	-	-	-	4.70	-	-	-	-	-
FEB	35.1	.38	.20	.66	.82	.07	-	-	-	-	1.20	-	-	-	-	-
MAR	29.2	.95	.44	1.92	.61	.05	-	-	-	-	.40	-	-	-	-	-
APR	5.8	-	-	-	-	-	-	-	-	-	.40	-	-	-	-	-
MAY	28.3	.51	.90	1.54	.41	.06	-	-	-	-	.50	-	-	-	-	-
JUN	100.5	.18	.09	.57	.38	.05	-	-	-	-	.20	-	-	-	-	-
JUL	49.7	.01	.42	.17	.07	-	-	-	-	-	1.30	-	-	-	-	-
AUG	82.8	.16	.01	.91	.72	.12	-	-	-	-	.30	-	-	-	-	-
SEP	68.0	.16	.23	.41	.27	.05	-	-	-	-	2.20	-	-	-	-	-
OCT	18.0	1.29	1.40	<.10	1.06	.55	-	-	-	-	1.70	-	-	-	-	-
NOV	20.2	.44	.11	.60	1.19	.14	-	-	-	-	.80	-	-	-	-	-
DEC	16.6	.25	.71	.27	1.18	.10	-	-	-	-	1.80	-	-	-	-	-
YEAR	466.1	.30	.25	.74	.60	.10	-	-	-	-	.90	-	-	-	-	-

Country : FINLAND  
Station : YLIMARKU  
Year : 1987

Sampler type : BULK  
Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	13.1	.31	.47	.77	.68	.12	-	-	-	-	.80	-	-	-	-	-
FEB	21.6	.67	.96	1.40	.33	.06	-	-	-	-	.50	-	-	-	-	-
MAR	37.0	1.21	.97	1.60	.36	.06	-	-	-	-	.30	-	-	-	-	-
APR	28.0	.89	1.90	2.97	.36	.16	-	-	-	-	.20	-	-	-	-	-
MAY	32.7	.63	1.60	2.58	.28	.11	-	-	-	-	1.00	-	-	-	-	-
JUN	45.7	.28	1.10	1.38	.27	.06	-	-	-	-	.20	-	-	-	-	-
JUL	11.7	-	1.80	2.68	.62	.23	-	-	-	-	.40	-	-	-	-	-
AUG	81.9	.47	.97	2.21	.25	.10	-	-	-	-	.30	-	-	-	-	-
SEP	102.5	.23	.79	1.18	.26	.12	-	-	-	-	1.40	-	-	-	-	-
OCT	43.9	1.39	1.20	2.63	.78	.16	-	-	-	-	.40	-	-	-	-	-
NOV	43.9	.55	.81	.77	.37	.06	-	-	-	-	.70	-	-	-	-	-
DEC	36.3	.30	.50	.48	.62	.06	-	-	-	-	.48	-	-	-	-	-
YEAR	498.3	.57	1.02	1.67	.38	.10	-	-	-	-	.48	-	-	-	-	-

Country : FINLAND  
Station : SIPOO  
Year : 1987

Sampler type : BULK  
Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	15.4	.52	.40	.90	.80	.09	-	-	-	-	1.10	-	-	-	-	-
FEB	31.8	.75	.66	1.26	.53	.06	-	-	-	-	.90	-	-	-	-	-
MAR	39.2	1.94	1.62	2.00	1.14	.15	-	-	-	-	1.50	-	-	-	-	-
APR	2.7	-	-	-	-	-	-	-	-	-	.40	-	-	-	-	-
MAY	53.9	.76	1.00	1.82	.98	.08	-	-	-	-	.30	-	-	-	-	-
JUN	95.8	.36	.51	1.65	.20	.08	-	-	-	-	.40	-	-	-	-	-
JUL	58.7	.37	.33	1.37	.34	.11	-	-	-	-	.20	-	-	-	-	-
AUG	65.2	.23	.18	.85	.22	.07	-	-	-	-	.20	-	-	-	-	-
SEP	143.6	.24	.31	.84	.38	.06	-	-	-	-	.50	-	-	-	-	-
OCT	18.3	.86	1.10	2.28	.65	.24	-	-	-	-	1.20	-	-	-	-	-
NOV	48.9	.73	.94	2.53	.44	.16	-	-	-	-	.80	-	-	-	-	-
DEC	11.5	.59	.70	.91	1.04	.12	-	-	-	-	1.70	-	-	-	-	-
YEAR	585.0	.54	.59	1.41	.48	.09	-	-	-	-	.59	-	-	-	-	-

Country : FINLAND  
Station : SULVA  
Year : 1987

Sampler type : BULK  
Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	8.1	.76	1.20	1.40	-	-	-	-	-	-	1.70	-	-	-	-	-
FEB	20.7	.63	.65	.92	.59	.12	-	-	-	-	1.20	-	-	-	-	-
MAR	22.5	1.54	1.04	1.65	.58	.12	-	-	-	-	.70	-	-	-	-	-
APR	10.5	-	-	-	.64	.20	-	-	-	-	-	-	-	-	-	-
MAY	35.4	.60	.42	1.48	.23	.08	-	-	-	-	.20	-	-	-	-	-
JUN	63.1	.28	.05	1.02	.15	.08	-	-	-	-	.20	-	-	-	-	-
JUL	36.1	.01	.41	.93	.42	.20	-	-	-	-	.70	-	-	-	-	-
AUG	117.5	.24	.21	.88	.27	.06	-	-	-	-	.30	-	-	-	-	-
SEP	102.4	.13	.21	.55	.20	.05	-	-	-	-	.20	-	-	-	-	-
OCT	20.6	2.49	1.70	4.66	2.00	1.18	-	-	-	-	-	-	-	-	-	-
NOV	55.7	.60	.67	.74	.30	.08	-	-	-	-	.40	-</td				

Country : SWEDEN  
 Station : ASPRETTEN  
 Year : 1987

Sampler type : WET ONLY  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N			
JAN	11.0	.39	.17	.67	.87	.12	2.70	.11	-	8.10	1.30	6.11	.97	1.79	.17	.54
FEB	17.0	.73	.53	.88	.22	.05	5.81	.18	-	14.00	.56	3.18	.76	1.30	.39	.84
MAR	18.0	1.14	.98	1.41	.28	.05	4.74	.22	-	20.90	.62	5.56	1.87	.92	.83	1.41
APR	5.0	1.24	1.75	2.97	.31	.08	5.71	.21	-	21.70	.59	1.42	1.21	.85	.59	1.58
MAY	54.0	.62	.58	1.18	.06	.02	3.33	.10	-	9.80	.24	.80	.84	.87	.37	1.37
JUN	63.0	.39	.23	1.14	.09	.02	1.89	.06	-	7.80	.22	.69	1.14	.84	.33	1.25
JUL	47.0	.07	-	.32	.05	.01	.79	.04	-	5.40	.17	.51	.74	.47	.27	.83
AUG	63.0	.22	.11	.80	.09	.12	1.90	.04	-	4.50	.21	.66	.77	.70	.28	.55
SEP	64.0	.38	.25	.66	.23	.03	2.24	.06	-	7.10	.47	-	-	.73	-	-
OCT	41.0	.61	.58	1.16	.30	.08	3.45	.17	-	16.10	.62	1.51	1.53	1.11	1.07	2.07
NOV	60.0	.58	.30	.81	.43	.06	4.95	.11	-	8.60	.81	1.27	.83	2.18	.40	.63
DEC	72.0	.20	.14	.30	.11	.02	3.53	.14	-	12.80	.40	1.02	.46	2.16	.30	.25
YEAR	515.0	.42	.34	.82	.19	.05	2.98	.10	-	9.56	.42	2.07	1.01	1.16	.45	1.03

Country : SWEDEN  
 Station : RICKLEÅ  
 Year : 1987

Sampler type : WET ONLY  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N		
JAN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEB	31.0	.32	.27	.55	.04	.01	-	-	-	.08	-	-	-	-	-
MAR	33.0	.99	.69	1.21	.17	.03	-	-	-	.40	-	-	-	-	-
APR	6.0	.28	.15	.64	.20	.04	-	-	-	.37	-	-	-	-	-
MAY	24.0	.54	.67	1.77	.03	.02	-	-	-	.15	-	-	-	-	-
JUN	63.0	.12	.09	.51	.07	.01	-	-	-	.11	-	-	-	-	-
JUL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AUG	63.0	-	-	.33	.15	.02	-	-	-	.29	-	-	-	-	-
SEP	63.0	.14	.08	.44	.08	.01	-	-	-	.15	-	-	-	-	-
OCT	53.0	.72	1.15	1.79	.42	.07	-	-	-	.82	-	-	-	-	-
NOV	61.0	.58	.37	1.01	.22	.03	-	-	-	.41	-	-	-	-	-
DEC	18.0	-	.01	.27	.28	.03	-	-	-	.40	-	-	-	-	-
YEAR	415.0	.44	.40	.83	.16	.03	-	-	-	.32	-	-	-	-	-

Country : SWEDEN  
 Station : VAVIHILL  
 Year : 1987

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N		
JAN	36.0	.44	.34	.62	1.41	.16	-	-	-	2.50	10.60	-	1.80	.75	1.77
FEB	44.1	.69	.93	1.40	1.23	.15	-	-	-	2.00	17.80	-	4.00	1.23	2.03
MAR	35.5	1.26	1.22	1.72	1.09	.14	-	-	-	.60	5.20	-	1.10	1.97	3.67
APR	54.3	.72	.89	1.15	.26	.03	-	-	-	1.50	2.20	-	.60	.84	1.77
MAY	71.8	.75	.68	1.05	.33	.04	-	-	-	1.40	1.80	-	1.00	.68	1.69
JUN	117.3	.36	.43	.98	.37	.06	-	-	-	1.60	1.70	-	.70	.59	1.69
JUL	133.7	.28	.50	.94	.70	.15	-	-	-	1.50	1.90	-	.90	.82	2.42
AUG	82.6	.12	.41	.63	.68	.12	-	-	-	2.10	1.60	-	.90	.68	1.85
SEP	83.3	.46	.49	.90	1.03	.15	-	-	-	1.00	6.20	-	1.40	1.56	2.61
OCT	37.3	.88	.86	2.21	1.22	.11	-	-	-	1.00	3.80	-	1.80	.87	1.85
NOV	79.5	.74	.72	1.57	.50	.07	-	-	-	1.40	3.80	-	2.10	.66	1.50
DEC	80.7	.64	.73	1.51	.62	.08	-	-	-	1.51	5.54	-	1.49	1.02	2.11
YEAR	856.1	.53	.62	1.14	.70	.10	-	-	-	-	-	-	-	-	-

Country : SWEDEN

Station : RORVIK

Sampler type : WET ONLY

Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N			
JAN	6.8	.96	.72	1.84	1.52	.19	-	-	-	-	3.20	7.30	-	2.60	.50	1.45
FEB	41.6	.63	.43	.92	1.30	.16	-	-	-	-	2.30	6.00	-	2.00	.96	1.53
MAR	37.5	.73	.65	.71	3.41	.34	-	-	-	-	5.00	5.80	-	2.10	1.26	2.38
APR	28.1	1.26	1.50	2.10	3.35	.04	-	-	-	-	.70	3.30	-	1.30	1.53	2.76
MAY	64.5	.31	.37	.65	.39	.05	-	-	-	-	.60	.90	-	.90	.69	1.44
JUN	117.7	.43	.41	.95	1.51	.20	-	-	-	-	2.80	1.10	-	.90	.65	1.35
JUL	108.2	.25	.47	.77	.37	.07	-	-	-	-	.80	1.20	-	.60	.56	1.28
AUG	59.6															

Country : USSR  
Station : SYRVE  
Year : 1987

Sampler type : BULK  
Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	14.7	2.12	1.60	1.81	11.28	-	-	-	-	-	-	.26	.60	1.66	.04	.40
FEB	37.4	1.07	.94	1.44	1.41	-	-	-	-	-	-	.10	.52	.90	.05	.48
MAR	14.1	2.61	1.78	2.89	1.78	-	-	-	-	-	-	.30	2.19	1.17	.03	.18
APR	-	-	-	-	-	-	-	-	-	-	-	.22	-	.06	.30	
MAY	70.5	1.09	1.15	1.60	.85	-	-	-	-	-	-	.08	.40	.68	.01	.36
JUN	55.8	.33	.70	.99	1.19	-	-	-	-	-	-	.06	.49	.59	.02	.25
JUL	47.9	.05	.02	.86	.91	-	-	-	-	-	-	.05	.53	.50	.05	.24
AUG	92.3	.11	.16	.46	.57	-	-	-	-	-	-	.12	.39	.38	.02	.45
SEP	62.2	.21	.17	.64	1.13	-	-	-	-	-	-	.04	.38	.73	.03	.20
OCT	22.8	.83	.23	1.76	2.75	-	-	-	-	-	-	.12	.09	.07	.06	.18
NOV	66.6	.88	.60	.91	2.38	-	-	-	-	-	-	.08	.16	.06	.07	.17
DEC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
YEAR	484.3	.63	.57	1.06	1.56	-	-	-	-	-	-	.12	.54	.67	.04	.29

Country : USSR  
Station : RUTSAVA  
Year : 1987

Sampler type : BULK  
Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	24.5	1.06	.43	-	-	-	-	-	-	-	-	12.47	2.59	5.00	.62	3.04
FEB	30.8	1.40	.92	-	-	-	-	-	-	-	-	3.61	3.15	1.94	.97	9.60
MAR	11.0	2.36	5.68	-	-	-	-	-	-	-	-	-	-	-	-	-
APR	9.5	1.52	2.15	-	-	-	-	-	-	-	-	.40	.48	1.71	.09	.55
MAY	46.7	1.30	.72	-	-	-	-	-	-	-	-	-	1.47	-	.21	1.39
JUN	68.8	.54	.52	-	-	-	-	-	-	-	-	.24	.57	1.37	.13	.62
JUL	75.5	.09	.07	-	-	-	-	-	-	-	-	.25	.52	1.44	.04	.60
AUG	141.0	.28	.15	-	-	-	-	-	-	-	-	.17	.35	1.27	.10	.40
SEP	100.8	.20	.12	-	-	-	-	-	-	-	-	.36	.88	1.16	.35	1.21
OCT	19.1	1.02	.97	1.43	.52	-	-	-	-	-	-	.75	.72	1.58	.22	.86
NOV	123.4	.31	.07	.87	.55	-	-	-	-	-	-	-	-	-	-	-
DEC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
YEAR	651.1	.51	.39	.95	.55	-	-	-	-	-	-	2.28	1.19	1.93	.30	2.03

Country : USSR  
Station : LAHEMAA  
Year : 1987

Sampler type : BULK  
Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S	A-SO4S	NO2N	T-NO3N	T-NHAN
JAN	9.6	.95	.78	1.88	1.04	-	-	-	-	-	-	13.55	.91	5.00	.09	.93
FEB	15.1	.82	6.32	1.30	1.11	-	-	-	-	-	-	1.38	.92	1.29	.11	.89
MAR	6.7	1.51	5.04	6.05	.48	-	-	-	-	-	-	1.24	-	1.22	-	-
APR	8.1	.12	.04	.56	.38	-	-	-	-	-	-	.48	.76	1.48	.11	.88
MAY	65.0	.74	1.18	1.48	.11	-	-	-	-	-	-	.47	.88	.63	.06	.63
JUN	43.0	.27	.23	.98	.07	-	-	-	-	-	-	.38	.94	.24	.08	.62
JUL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AUG	129.0	.03	.03	.68	.55	-	-	-	-	-	-	.21	1.27	.47	.09	.20
SEP	92.4	.07	.01	.34	.29	-	-	-	-	-	-	.14	.39	.65	.05	.17
OCT	6.3	.55	.32	.56	.25	-	-	-	-	-	-	.14	.21	.65	-	-
NOV	32.9	.62	.41	1.33	.75	-	-	-	-	-	-	.24	-	.70	-	-
DEC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
YEAR	408.1	.31	.60	.95	.41	-	-	-	-	-	-	1.82	.79	1.23	.08	.62

Country : POLAND

Station : LEBA  
Year : 1987

Sampler type : WET ONLY  
Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAR	18.3	1.45	.56	1.18	.19	.09	-	-	-	-	1.08	-	-	-	-	-
APR	29.2	.81	.66	1.76	.32	.13	-	-	-	-	1.39	-	-	-	-	-
MAY	36.7	1.48	1.13	2.39	.24	.12	-	-	-	-	1.07	-	-	-	-	-
JUN	82.8	.62	1.17	1.13	.52	.08	-	-	-	-	.89	-	-	-	-	-
JUL	76.1	.76	1.22	2.16	.53	.15	-	-	-	-	1.62	-	-	-	-	-
AUG	100.1	.67	1.07	2.13	.50	.18	-	-	-	-	1.57	-	-	-	-	-
SEP	97.4	.47	.82	1.91	.71	.17	-	-	-	-	1.84	-	-	-	-	-
OCT	63.5	.73	.82	2.26	.23	.10	-	-	-	-	1.01	-	-	-	-	-
NOV	76.4	.62	.28	1.48	.85	.11	-	-	-	-	1.59	-	-	-	-	-
DEC	50.3	.77	.89	1.33	1.56	.22	-	-	-	-	2.88	-	-	-	-	-
YEAR	630.8	.73	.90	1.81	.61	.14	-	-	-	-	1.53	-	-	-	-	-

Country : DDR  
Station : KAP ARKONA  
Year : 1987

Sampler type : WET ONLY  
Sampling period : WEEKLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	25.4	.70	.30	1.70	2.40	.40	-	-	-	-	4.60	9.50	3.60	-	-	-
FEB	26.4	.40	.40	1.76	.50	.20	-	-	-	-	1.10	15.00	3.60	-	-	-
MAR	21.5	1.40	2.20	4.23	.80	.30	-	-	-	-	2.00	4.50	4.60	-	-	-
APR	36.9	.60	1.70	1.86	.50	.10	-	-	-	-	.80	3.00	4.50	-	-	-
MAY	36.8	1.70	2.60	4.48	1.40	2.60	-	-	-	-	2.40	1.20	2.10	-	-	-
JUN	65.5	8.80	1.40	2.56	.50	.10	-	-	-	-	.90	.50	4.20	-	-	-
JUL	111.1	.40	.80	1.68	1.40	.20	-	-	-	-	2.00	.70	1.70	-	-	-
AUG	36.4	1.10	1.20	2.00	1.20	.20	-	-	-	-	1.80	1.60	2.80	-	-	-
SEP	84.5	.40	.50	1.42	.90	.10	-	-	-	-	1.40	.90	1.90	-	-	-
OCT	4.5	-	-	-	-	-	-	-	-	-	-	3.90	2.90	-	-	-
NOV	66.5	.50	.60	1.67	2.70	.50	-	-	-	-	5.10	3.20	2.30	-	-	-
DEC	34.3	.40	.60	2.22	1.00	.20	-	-	-	-	1.80	7.80	3.80	-	-	-
YEAR	549.8	1.62	1.01	2.11	1.25	.38	-	-	-	-	2.15	4.32	3.17	-	-	-

Country : FRG  
Station : KIEL BIGHT  
Year : 1987

Sampler type : WET ONLY  
Sampling period : WEEKLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
APR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAY	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JUN	45.0	-	-	-	-	-	8.30	-	-	5.00	-	-	-	-	-	-
JUL	35.0	-	-	-	-	-	11.30	-	-	19.90	-	-	-	-	-	-
AUG	32.0	-	-	-	-	-	7.30	-	-	10.40	-	-	-	-	-	-
SEP	9.0	-	-	-	-	-	16.70	-	-	-	-	-	-	-	-	-
OCT	21.0	-	-	-	-	-	40.30	-	-	-	-	-	-	-	-	-
NOV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DEC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
YEAR	142.0	-	-	-	-	-	14.08	-	-	11.20	-	-	-	-	-	-

Country : FRG  
 Station : DANISCH-NIENHOF  
 Year : 1987

Sampler type : WET ONLY  
 Sampling period : WEEKLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
APR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MAY	107.0	.10	.11	.14	-	-	2.49	.06	-	7.43	1.13	-	-	-	-	-
JUN	98.0	.09	.15	1.35	-	-	4.91	.07	-	10.70	2.30	-	-	-	-	-
JUL	81.0	1.05	.97	1.63	-	-	4.10	.05	-	11.53	1.59	-	-	-	-	-
AUG	74.0	.47	.54	.82	-	-	2.10	.04	-	7.40	1.12	-	-	-	-	-
SEP	112.0	.81	.80	1.44	-	-	4.32	1.42	-	3.25	1.39	-	-	-	-	-
OCT	82.0	.74	.59	1.54	-	-	9.61	.41	-	3.52	1.67	-	-	-	-	-
NOV	91.0	1.17	.61	2.07	-	-	8.08	.49	-	3.36	8.14	-	-	-	-	-
DEC	70.0	.97	.96	.70	-	-	10.39	.83	-	9.11	12.22	-	-	-	-	-
YEAR	715.0	.65	.57	1.21	-	-	5.55	.44	-	6.88	3.42	-	-	-	-	-

## ANNEX 4

## Annual statistics on HELCOM/EGAP data 1988

Country : DENMARK  
 Station : KELDSNR  
 Year : 1987

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	7.5	.65	.55	1.09	-	-	-	-	-	13.86	7.42	2.62	-	-	-	-
FEB	12.2	1.71	1.21	2.02	-	-	-	-	-	2.28	9.19	3.27	-	-	-	-
MAR	10.6	1.67	1.42	1.70	-	-	-	-	-	1.57	5.29	3.07	-	-	-	-
APR	34.1	1.19	1.56	1.38	-	-	-	-	-	1.44	2.78	3.41	-	-	-	-
MAY	28.1	.95	1.24	1.45	-	-	-	-	-	1.86	1.88	1.47	-	-	-	-
JUN	64.8	.82	.87	1.35	-	-	-	-	-	1.49	.97	1.68	-	-	-	-
JUL	59.5	.47	.76	1.35	-	-	-	-	-	2.50	1.39	1.86	-	-	-	-
AUG	39.9	.74	1.44	1.15	-	-	-	-	-	1.47	1.32	2.20	-	-	-	-
SEP	56.4	.68	1.08	1.21	-	-	-	-	-	2.27	.85	1.71	-	-	-	-
OCT	31.1	.94	1.28	1.87	-	-	-	-	-	3.39	8.01	3.22	-	-	-	-
NOV	23.7	.56	.57	.81	-	-	-	-	-	10.85	4.06	2.17	-	-	-	-
DEC	16.7	.60	.86	1.43	-	-	-	-	-	5.95	4.41	2.02	-	-	-	-
YEAR	384.8	.81	1.07	1.36	-	-	-	-	-	2.98	3.96	2.39	-	-	-	-

DATA COVERAGE 1988		*	**	PRECIPITATION												AIR	
		mm	mm	NO <sub>3</sub>	NH <sub>4</sub>	SO <sub>4</sub>	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO <sub>2</sub>	NO <sub>2</sub>	TN <sub>x</sub>	TNy
SF	VANHANKYLANMAA	11	BM	12	12	12	12	12	12	12	12	12	12	-	-	-	-
SF	HAILUOTO	12	BM	12	12	12	12	12	12	12	12	12	12	-	-	-	-
SF	HAILUOTO	12	WM	12	12	12	12	12	12	12	12	12	12	-	-	-	-
SF	VIROLAHTI	13	BD	12	12	12	12	12	12	12	12	12	12	-	-	-	-
SF	VIROLAHTI	13	BM	12	12	12	12	12	12	12	12	12	12	-	-	-	-
SF	UTØ	14	BD	12	12	12	12	12	12	10	10	10	10	-	-	-	-
SF	HAAPASAARI	15	WM	10	10	10	-	10	10	10	10	10	10	-	-	-	-
SF	TVÆRMINNE	16	BM	12	12	12	12	11	11	-	-	-	-	-	-	-	-
SF	JOMALA	17	BM	12	12	12	12	12	12	-	-	-	-	-	-	-	-
SF	YLIMARKKU	19	BM	12	12	12	12	12	12	-	-	-	-	-	-	-	-
SF	SIPOO	20	BM	12	11	12	12	9	9	-	-	-	-	-	-	-	-
SF	SULVA	21	BM	12	11	12	12	12	12	-	-	-	-	-	-	-	-
SF	KORPOO	22	BM	12	11	10	11	11	11	-	-	-	-	-	-	-	-
SE	ARUP	31	WM	12	12	12	12	12	12	12	12	12	12	-	-	-	-
SE	ASPVRETEN	32	WM	12	12	12	12	12	12	12	12	12	12	-	-	-	-
SE	RICKLEÅ	33	BM	11	11	11	11	11	11	-	-	-	-	-	-	-	-
SE	VÄVİHILL	34	WD	12	12	12	12	12	12	12	12	12	12	-	-	-	-
SE	RØRVIK	35	WD	12	12	12	12	12	12	12	12	12	12	-	-	-	-
SE	HOBURG	36	WD	12	12	12	12	12	12	12	12	12	12	-	-	-	-
SU	NIDA	41	WD	12	11	12	12	12	12	-	-	-	-	-	-	-	-
SU	SYRVE	42	WD	12	12	12	12	12	12	-	-	-	-	-	-	-	-
SU	RUTSAVA	43	WD	12	11	12	12	12	12	-	-	-	-	-	-	-	-
SU	LAHEMAA	44	WD	12	12	10	12	12	12	-	-	-	-	-	-	-	-
PL	LEBA	51	BD	12	12	12	12	12	12	-	-	-	-	-	-	-	-
DD	KAPARKONA	61	WW	12	12	12	12	12	12	-	-	-	-	-	-	-	-
DE	DANISCH-NIENHOF	72	WW	12	12	12	12	12	12	-	-	-	-	-	-	-	-
DK	KELDSNØR	81	WD	12	11	11	12	12	12	-	-	-	-	-	-	-	-

Precipitation and air data reported to HELCOM.  
Number of monthly averages reported per station.

\*) Internal station nr.  
\*\*) B - Bulk, W - Wet only  
M - Monthly, W - Weekly, D - Daily

TN<sub>x</sub> = HNO<sub>3</sub> + NO<sub>3</sub>  
TNy = NH<sub>3</sub> + NH<sub>4</sub><sup>+</sup>

Country : FINLAND  
Station : VANHANKYLANMAA  
Year : 1988

Sampler type : BULK  
Sampling period : MONTHLY

mm	NO <sub>3</sub> N	NH <sub>4</sub> N	SO <sub>4</sub> S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO <sub>2</sub> S	A-SO <sub>4</sub> S	NO <sub>2</sub> N	T-NO <sub>3</sub> N	T-NH <sub>4</sub> N
JAN	42.0	1.40	.69	3.84	-	.37	11.40	.26	-	27.00	-	-	-	-	-
FEB	39.0	1.30	.76	3.53	-	.25	10.60	.15	-	14.00	-	-	-	-	-
MAR	58.0	.90	.63	2.13	-	.10	7.80	.21	-	17.00	-	-	-	-	-
APR	31.0	.78	1.06	2.90	-	.15	5.10	.17	-	16.00	-	-	-	-	-
MAY	7.0	.56	1.38	1.94	-	.23	1.10	.17	-	15.00	-	-	-	-	-
JUN	27.0	.37	.68	1.32	-	.11	.50	.12	-	15.00	-	-	-	-	-
JUL	33.0	1.18	1.71	4.68	-	.17	1.70	.11	-	6.00	-	-	-	-	-
AUG	94.0	.44	.90	1.73	-	.10	3.80	.17	-	12.00	-	-	-	-	-
SEP	91.0	.30	.39	.85	-	.07	3.80	.08	-	11.00	-	-	-	-	-
OCT	52.0	1.12	.88	2.02	-	.40	10.10	.21	-	1.00	-	-	-	-	-
NOV	19.0	.81	.62	1.34	-	.37	6.60	.15	-	14.00	-	-	-	-	-
DEC	61.0	.48	.22	1.66	-	.20	1.70	.06	-	8.00	-	-	-	-	-
YEAR	554.0	.74	.73	2.14	-	.18	5.48	.15	-	13.45	-	-	-	-	-

Country : FINLAND  
Station : HAILUOTO  
Year : 1988

Sampler type : BULK  
Sampling period : MONTHLY

mm	NO <sub>3</sub> N	NH <sub>4</sub> N	SO <sub>4</sub> S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO <sub>2</sub> S	A-SO <sub>4</sub> S	NO <sub>2</sub> N	T-NO <sub>3</sub> N	T-NH <sub>4</sub> N	
JAN	56.6	1.44	.83	1.62	.92	.25	-	-	-	1.10	-	-	-	-	-	-
FEB	24.2	1.20	1.00	1.83	.83	.10	-	-	-	.60	-	-	-	-	-	-
MAR	28.0	1.96	2.00	3.83	.80	.16	-	-	-	.50	-	-	-	-	-	-
APR	13.8	1.52	1.70	1.30	1.19	.12	-	-	-	1.00	-	-	-	-	-	-
MAY	14.5	1.22	2.30	3.87	.36	.15	-	-	-	.50	-	-	-	-	-	-
JUN	20.7	.01	.01	1.28	.28	.09	-	-	-	.20	-	-	-	-	-	-
JUL	72.0	.10	.44	.48	.25	.05	-	-	-	.20	-	-	-	-	-	-
AUG	67.8	.17	.28	.79	.15	.02	-	-	-	.20	-	-	-	-	-	-

Country : FINLAND  
 Station : VIROLAHTI  
 Year : 1988

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	49.0	.66	.53	1.16	.47	.09	-	-	-	.90	8.10	2.10	-
FEB	47.0	1.22	1.00	3.17	.40	.18	-	-	-	1.00	7.60	2.60	-
MAR	72.0	1.05	.96	2.69	.17	.13	-	-	-	.60	7.80	3.80	-
APR	25.0	.63	.74	1.38	.19	.06	-	-	-	.50	2.70	1.20	-
MAY	9.0	.63	2.41	2.39	.14	.23	-	-	-	.50	2.00	1.60	-
JUN	41.0	.17	.19	.38	.19	.02	-	-	-	.20	1.50	1.30	-
JUL	42.0	.24	.44	.69	.13	.06	-	-	-	.30	1.60	1.60	-
AUG	149.0	.28	.44	.99	.15	.06	-	-	-	.50	1.70	1.00	-
SEP	152.0	.26	.29	.68	.27	.05	-	-	-	1.60	2.30	.90	1.20
OCT	61.0	.51	.47	.93	.81	.16	-	-	-	2.40	2.40	.80	1.40
NOV	22.0	.49	.30	.69	1.33	.15	-	-	-	.70	5.00	1.00	2.20
DEC	55.0	.49	.27	.77	.38	.06	-	-	-				
YEAR	724.0	.49	.51	1.19	.33	.09	-	-	-	.67	3.70	1.58	1.60

Country : FINLAND  
 Station : VIROLAHTI  
 Year : 1988

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	67.5	.92	.84	1.75	.64	.15	-	-	-	.90	-	-	-
FEB	46.9	1.87	1.70	2.01	1.02	.29	-	-	-	1.90	-	-	-
MAR	81.7	1.34	.17	.67	.34	.16	-	-	-	.50	-	-	-
APR	26.4	1.04	2.20	3.34	.69	.21	-	-	-	.70	-	-	-
MAY	12.9	1.07	1.90	3.86	.49	.42	-	-	-	.80	-	-	-
JUN	47.5	.01	.17	.67	.37	.08	-	-	-	.40	-	-	-
JUL	59.1	.31	.80	.96	.45	.12	-	-	-	.50	-	-	-
AUG	111.6	.28	.23	.99	.17	.06	-	-	-	.40	-	-	-
SEP	174.1	.24	.24	.78	.24	.07	-	-	-	.30	-	-	-
OCT	66.1	.63	.62	1.23	.83	.19	-	-	-	2.20	-	-	-
NOV	27.4	.50	.05	.62	1.01	.13	-	-	-	1.60	-	-	-
DEC	83.0	.57	.46	.86	.44	.07	-	-	-	.70	-	-	-
YEAR	804.2	.62	.54	1.13	.46	.12	-	-	-	.76	-	-	-

Country : FINLAND  
 Station : UTO  
 Year : 1988

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	33.0	2.37	1.31	3.30	3.58	.50	-	-	-	7.60	4.60	1.70	2.00
FEB	27.0	2.27	1.03	2.89	2.52	.32	-	-	-	5.00	5.00	2.40	2.20
MAR	32.0	1.18	.95	1.44	1.86	.14	-	-	-	3.20	6.00	2.70	1.80
APR	23.0	1.19	1.22	2.57	1.51	.16	-	-	-	2.70	3.20	1.10	3.50
MAY	23.0	.72	1.19	2.46	.42	.17	-	-	-	.80	2.00	1.30	2.40
JUN	35.0	.35	.43	1.26	.43	.10	-	-	-	.80	2.90	1.40	4.50
JUL	68.0	.52	.75	2.03	.80	.12	-	-	-	1.50	1.70	1.90	2.20
AUG	53.0	.54	.38	.94	.76	.09	-	-	-	1.30	1.80	-	3.40
SEP	45.0	.42	.35	.68	1.47	.19	-	-	-	3.00	2.00	.80	2.40
OCT	67.0	.83	.59	.89	3.68	.41	-	-	-	6.50	2.40	1.10	1.10
NOV	28.0	.97	.48	1.38	8.56	.94	-	-	-	14.90	3.00	.60	.80
DEC	69.0	.75	.36	.73	3.21	.37	-	-	-	5.90	3.00	.70	1.10
YEAR	503.0	.90	.67	1.51	2.33	.28	-	-	-	4.30	3.13	1.43	2.28

Country : FINLAND  
 Station : HAAPASAARI  
 Year : 1988

Sampler type : WET ONLY  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	42.0	.50	.53	1.07	-	.19	6.80	.11	-	35.00	-	-	-
FEB	39.0	.93	.56	2.29	-	.16	8.20	.15	-	12.00	-	-	-
MAR	58.0	.85	.60	1.74	-	.08	6.20	.22	-	19.00	-	-	-
APR	31.0	1.26	1.56	4.36	-	.20	9.20	.32	-	30.00	-	-	-
MAY	7.0	.87	1.79	3.22	-	.26	1.00	.12	-	21.00	-	-	-
JUN	27.0	.35	<.01	1.44	-	.08	2.90	.10	-	36.00	-	-	-
JUL	33.0	.76	.43	3.34	-	.08	1.40	.08	-	11.00	-	-	-
AUG	94.0	.40	.59	1.45	-	.07	3.20	.20	-	18.00	-	-	-
SEP	-	-	-	-	-	-	-	-	-	-	-	-	-
OCT	-	-	-	-	-	-	-	-	-	-	-	-	-
NOV	19.0	.59	.55	1.08	-	.31	8.30	.13	-	22.00	-	-	-
DEC	61.0	.37	.19	1.11	-	.13	1.70	.06	-	9.00	-	-	-
YEAR	411.0	.63	.60	1.87	-	.13	4.73	.16	-	19.73	-	-	-

Country : FINLAND  
 Station : TVÄRMINNE  
 Year : 1988

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N

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Country : FINLAND  
 Station : YLI-MARKU  
 Year : 1988

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	54.7	.90	.92	1.15	.58	.08	-	-	-	-	.80	-	-	-	-	-
FEB	48.7	1.11	.98	1.34	.73	.11	-	-	-	-	1.00	-	-	-	-	-
MAR	27.9	1.50	1.70	2.14	.67	.14	-	-	-	-	.60	-	-	-	-	-
APR	20.4	1.37	1.60	1.65	.54	.13	-	-	-	-	.60	-	-	-	-	-
MAY	42.4	.59	.97	1.87	.32	.10	-	-	-	-	.30	-	-	-	-	-
JUN	39.3	.51	.47	1.64	.70	.10	-	-	-	-	.30	-	-	-	-	-
JUL	132.9	.14	.12	.57	.32	.03	-	-	-	-	.30	-	-	-	-	-
AUG	108.6	.20	.53	.78	.24	.03	-	-	-	-	.40	-	-	-	-	-
SEP	71.0	.32	1.00	1.37	.37	.16	-	-	-	-	1.10	-	-	-	-	-
OCT	49.7	.40	.75	.87	.35	.13	-	-	-	-	3.70	-	-	-	-	-
NOV	15.3	.97	-	1.48	2.60	.21	-	-	-	-	-	-	-	-	-	-
DEC	37.9	.55	.87	.71	1.02	.13	-	-	-	-	1.60	-	-	-	-	-
YEAR	648.8	.52	.71	1.10	.51	.09	-	-	-	-	.65	-	-	-	-	-

Country : FINLAND  
 Station : SIPOO  
 Year : 1988

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	4.6	1.06	.88	1.63	.78	.13	-	-	-	-	1.60	-	-	-	-	-
FEB	65.2	1.52	1.10	2.23	.81	.13	-	-	-	-	1.50	-	-	-	-	-
MAR	65.5	1.50	2.10	3.00	-	-	-	-	-	-	1.30	-	-	-	-	-
APR	29.1	.82	.84	1.85	.62	.15	-	-	-	-	.80	-	-	-	-	-
MAY	9.6	-	3.70	1.60	-	-	-	-	-	-	-	-	-	-	-	-
JUN	25.0	.44	.12	1.61	1.02	.18	-	-	-	-	1.10	-	-	-	-	-
JUL	68.0	.51	.15	1.55	.61	.15	-	-	-	-	.80	-	-	-	-	-
AUG	106.8	.32	.10	1.06	.42	.07	-	-	-	-	.70	-	-	-	-	-
SEP	105.5	.31	.31	.86	.45	.14	-	-	-	-	.70	-	-	-	-	-
OCT	78.2	.35	.23	.76	.43	.11	-	-	-	-	1.80	-	-	-	-	-
NOV	11.2	.48	.68	1.40	-	-	-	-	-	-	3.20	-	-	-	-	-
DEC	70.7	.41	.20	.55	.55	.06	-	-	-	-	.80	-	-	-	-	-
YEAR	639.4	.64	.58	1.38	.55	.11	-	-	-	-	1.08	-	-	-	-	-

Country : FINLAND  
 Station : SULVA  
 Year : 1988

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	45.5	.89	.69	.93	.78	.18	-	-	-	-	1.20	-	-	-	-	-
FEB	43.1	-	.74	1.16	.43	.06	-	-	-	-	.50	-	-	-	-	-
MAR	26.4	.95	.64	1.36	.47	.07	-	-	-	-	4.00	-	-	-	-	-
APR	22.6	.58	.53	1.07	.38	.07	-	-	-	-	.40	-	-	-	-	-
MAY	28.0	.52	.55	1.48	.25	.10	-	-	-	-	.30	-	-	-	-	-
JUN	41.9	.35	.10	1.28	.18	.09	-	-	-	-	.30	-	-	-	-	-
JUL	112.2	.01	.04	.59	.15	.09	-	-	-	-	.20	-	-	-	-	-
AUG	114.9	.17	.20	.68	.20	.04	-	-	-	-	.50	-	-	-	-	-
SEP	78.0	.19	.09	.57	.31	.07	-	-	-	-	2.40	-	-	-	-	-
OCT	43.4	.09	.05	.91	1.10	.47	-	-	-	-	4.20	-	-	-	-	-
NOV	15.4	.72	1.07	1.30	2.40	.37	-	-	-	-	2.00	-	-	-	-	-
DEC	33.6	.56	.59	.40	1.24	.16	-	-	-	-	-	-	-	-	-	-
YEAR	605.0	.32	.31	.84	.46	.12	-	-	-	-	.89	-	-	-	-	-

Country : FINLAND

Station : KORPPOO

Year : 1988

Sampler type : BULK

Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	52.6	1.57	1.50	2.69	1.31	.22	-	-	-	-	2.30	-	-	-	-	-
FEB	43.6	1.52	1.20	2.01	1.03	.15	-	-	-	-	1.60	-	-	-	-	-
MAR	45.8	1.04	.76	1.45	.56	.08	-	-	-	-	.60	-	-	-	-	-
APR	32.6	.84	1.20	1.87	.37	.08	-	-	-	-	.50	-	-	-	-	-
MAY	29.9	.70	.92	2.17	.35	.14	-	-	-	-	.30	-	-	-	-	-
JUN	23.6	.68	-	3.57	.41	.58	-	-	-	-	.80	-	-	-	-	-
JUL	100.0	.26	1.50	.86	.53	.02	-	-	-	-	.80	-	-	-	-	-
AUG	108.7	.25	.38	.68	.25	.02	-	-	-	-	.30	-	-	-	-	-
SEP	65.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OCT	58.9	.66	.58	1.12	.96	.29	-									

Country : SWEDEN  
 Station : RICKLEÅ  
 Year : 1988

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	64.0	.73	.65	1.26	.23	.03	-	-	-	.39	-	-	-
FEB	69.0	.79	.42	.95	.35	.05	-	-	-	.65	-	-	-
MAR	32.0	.62	.41	1.40	.11	.03	-	-	-	.16	-	-	-
APR	11.0	.50	.79	1.52	.22	.07	-	-	-	.27	-	-	-
MAY	11.0	.46	1.17	2.14	.19	.06	-	-	-	.23	-	-	-
JUN	35.0	.50	.82	1.39	.09	.03	-	-	-	.15	-	-	-
JUL	79.0	.15	.15	.56	.17	.03	-	-	-	.23	-	-	-
AUG	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP	73.0	.20	.22	.53	.16	.02	-	-	-	.35	-	-	-
OCT	17.0	.57	.46	.98	.38	.08	-	-	-	.61	-	-	-
NOV	8.0	.15	.08	.21	.40	.05	-	-	-	.66	-	-	-
DEC	39.0	.22	.06	.19	.31	.04	-	-	-	.53	-	-	-
YEAR	438.0	.45	.39	.89	.22	.04	-	-	-	.38	-	-	-

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	139.0	.71	.56	1.47	.77	.10	-	-	-	1.30	8.50	1.90	2.50
FEB	108.0	.77	.49	1.23	1.64	.21	-	-	-	3.00	5.30	1.59	1.50
MAR	52.0	1.30	1.01	1.68	1.56	.19	-	-	-	3.40	3.90	1.87	1.10
APR	38.0	.79	1.17	1.84	1.13	.16	-	-	-	2.40	4.20	1.81	.80
MAY	18.0	.67	.92	2.04	.49	.20	-	-	-	1.00	1.80	1.45	.70
JUN	79.0	.34	.58	1.03	.20	.07	-	-	-	.70	1.10	1.53	.70
JUL	113.0	.55	.48	.86	.27	.05	-	-	-	.50	2.60	1.92	.60
AUG	70.0	.64	.86	1.09	1.60	.19	-	-	-	2.30	3.10	1.20	.80
SEP	99.0	.61	.58	1.02	1.34	.14	-	-	-	1.90	3.30	1.35	1.10
OCT	74.0	.52	.57	1.04	2.16	.24	-	-	-	3.30	3.80	1.37	1.10
NOV	37.0	.60	.91	.80	2.26	.25	-	-	-	3.00	5.10	1.43	2.20
DEC	86.0	.53	.61	.88	2.29	.26	-	-	-	4.30	4.10	.71	1.90
YEAR	913.0	.65	.65	1.17	1.26	.16	-	-	-	2.16	3.90	1.51	1.25

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	140.0	.69	.38	1.13	1.24	.15	-	-	-	2.30	4.90	1.87	2.80
FEB	87.0	.89	.52	1.26	3.10	.39	-	-	-	6.40	3.80	1.58	1.80
MAR	40.0	1.45	1.02	1.86	1.31	.16	-	-	-	2.00	3.40	1.73	1.90
APR	50.0	1.35	2.06	2.52	1.11	.16	-	-	-	2.30	2.30	1.73	1.50
MAY	24.0	.99	.90	1.98	.60	.10	-	-	-	1.40	1.60	1.54	1.30
JUN	13.0	1.05	1.31	2.30	1.02	.17	-	-	-	2.70	1.30	1.40	.67
JUL	156.0	.52	.66	1.10	1.05	.15	-	-	-	1.80	1.60	1.86	.90
AUG	72.0	1.00	.83	1.23	1.53	.18	-	-	-	2.20	1.80	1.46	1.40
SEP	79.0	.62	.54	.89	2.49	.28	-	-	-	3.70	3.00	1.73	1.50
OCT	92.0	.70	.65	.98	4.44	.52	-	-	-	7.00	3.10	3.45	2.20
NOV	30.0	.99	.82	.90	1.94	.21	-	-	-	3.10	4.20	2.93	4.00
DEC	50.0	.70	.45	1.06	3.53	.38	-	-	-	8.10	2.90	2.68	2.80
YEAR	833.0	.80	.71	1.26	2.03	.25	-	-	-	3.62	2.82	2.00	1.93

Country : SWEDEN  
 Station : HOBURG  
 Year : 1988

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	34.0	1.86	1.30	2.92	2.32	.34	-	-	-	3.40	7.10	2.48	2.20
FEB	30.0	1.80	.97	2.29	2.81	.40	-	-	-	3.90	4.10	2.13	1.20
MAR	15.0	1.80	1.86	2.85	1.50	.23	-	-	-	1.80	2.50	1.96	.60
APR	25.0	.79	.90	2.30	.55	.09	-	-	-	.80	1.20	1.08	.70
MAY	27.0	.47	.66	1.47	.14	.04	-	-	-	.40	1.20	1.16	.60
JUN	61.0	.38	1.23	1.38	.16	.11	-	-	-	.40	1.20	1.25	.40
JUL	96.0	.48	2.06	1.55	.60	.14	-	-	-	.70	1.20	1.33	.30
AUG	29.0	.55	3.74	1.35	.86	.11	-	-	-	2.30	.80	.98	.30
SEP	36.0	.85	1.77	1.45	2.53	.39	-	-	-	3.70	1.80	1.83	.40
OCT	18.0	1.25	.56	1.41	3.32	.51	-	-	-	5.10	1.90	1.32	.80
NOV	19.0	.76	.28	.64	2.07	.25	-	-	-	2.90	2.40	.74	1.20
DEC	22.0	.95	.53	.66	3.08	.33	-	-	-	4.50	2.60	.60	1.00
YEAR	412.0	.85	1.49	1.66	1.34	.22	-	-	-	1.98	2.30	1.40	.81

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N\*




<tbl\_r

Country : USSR  
 Station : RUTSAVA  
 Year : 1988

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S A-SO4S	NO2N T-NO3N T-NH4N*		
JAN	36.6	.70	.60	2.02	2.20	-	-	-	-	-	3.30	1.40	1.70	.30	1.60
FEB	29.8	1.40	.40	.99	1.30	-	-	-	-	-	7.00	1.40	1.40	.40	1.40
MAR	39.7	.50	.10	1.11	1.10	-	-	-	-	-	2.30	1.40	1.80	.20	1.30
APR	32.0	.60	.60	.80	1.20	-	-	-	-	-	.70	.80	1.50	.10	.80
MAY	19.3	.50	.20	1.56	.50	-	-	-	-	-	.60	.90	1.80	.20	.90
JUN	70.8	-	.30	.67	.40	-	-	-	-	-	.20	.60	1.80	.20	.70
JUL	150.6	.20	.20	1.06	.50	-	-	-	-	-	.10	.90	2.00	.20	.70
AUG	30.9	.30	.10	1.33	.80	-	-	-	-	-	.10	.60	1.50	.10	.50
SEP	92.4	.50	.20	.57	1.50	-	-	-	-	-	.10	.50	1.50	.10	.50
OCT	70.4	.50	.20	.32	1.00	-	-	-	-	-	.50	1.30	1.40	.20	.60
NOV	105.8	.70	.50	.69	1.30	-	-	-	-	-	.70	.50	1.60	.10	.30
DEC	82.5	.50	.40	1.03	2.00	-	-	-	-	-	.90	3.90	1.70	.10	.40
YEAR	760.8	.51	.31	.90	1.12	-	-	-	-	-	1.38	1.18	1.64	.18	.81

\*) Reporting NH4+

Country : USSR  
 Station : LAHEMAA  
 Year : 1988

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S A-SO4S	NO2N T-NO3N T-NH4N*		
JAN	2.1	2.20	1.20	3.51	1.10	-	-	-	-	-	.80	.90	.80	.10	1.10
FEB	5.5	.50	.10	2.27	.30	-	-	-	-	-	1.30	1.60	1.40	.20	1.30
MAR	36.3	.70	.40	1.55	.60	-	-	-	-	-	.90	1.90	1.40	.10	1.40
APR	24.2	.30	.10	.52	1.00	-	-	-	-	-	.40	1.00	1.40	.10	.80
MAY	19.9	.80	1.30	1.86	.50	-	-	-	-	-	.30	.70	.70	.10	.50
JUN	10.1	.10	-	1.07	.40	-	-	-	-	-	.20	.80	.60	.10	.70
JUL	107.1	.10	.10	1.08	.20	-	-	-	-	-	.20	.60	1.20	.10	.30
AUG	57.5	.20	.60	1.77	.30	-	-	-	-	-	.10	.50	.70	-	.30
SEP	34.8	.30	.30	.76	.50	-	-	-	-	-	.10	.50	-	-	.30
OCT	41.0	.40	.30	.57	.30	-	-	-	-	-	.10	.30	2.80	.10	.40
NOV	39.0	.20	.40	.37	1.50	-	-	-	-	-	.20	.30	1.90	.50	.20
DEC	41.9	.30	-	.30	1.20	-	-	-	-	-	.50	.20	1.40	-	.20
YEAR	419.4	.30	.35	1.03	.57	-	-	-	-	-	.43	.77	1.30	.16	.62

\*) Reporting NH4+

Country : POLAND  
 Station : LEBA  
 Year : 1988

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S A-SO4S	NO2N T-NO3N T-NH4N	
JAN	39.2	.71	.49	1.17	.64	.10	9.70	-	-	48.00	1.33	-	-	-
FEB	29.7	.76	.48	1.51	1.20	.16	10.00	-	-	25.60	2.39	-	-	-
MAR	35.6	.72	.47	1.47	1.15	.14	19.00	-	-	33.00	2.12	-	-	-
APR	35.2	.66	.90	2.17	1.01	.14	14.50	-	-	28.00	2.03	4.10	.30	1.80
MAY	26.2	.63	2.74	4.41	.44	.10	7.60	-	-	36.60	1.18	4.20	.80	1.30
JUN	59.0	.30	.90	1.11	.24	.07	6.00	-	-	27.70	.83	3.20	.20	1.50
JUL	225.0	.35	.88	1.50	.18	.05	14.00	-	-	36.00	1.02	9.00	1.40	1.30
AUG	40.9	.92	1.32	2.18	.63	.12	22.00	-	-	109.00	2.47	6.00	.40	1.80
SEP	64.5	.53	.67	1.16	1.07	.17	15.00	-	-	44.00	2.60	11.00	.50	.70
OCT	17.7	1.12	.70	2.32	3.21	.31	17.00	-	-	135.00	5.14	15.00	.50	.80
NOV	42.8	.85	.39	.88	3.63	.42	11.00	-	-	78.00	6.40	11.50	.40	.80
DEC	56.3	.67	.30	1.30	1.42	.16	11.00	-	-	24.50	2.67	9.50	.60	1.00
YEAR	672.1	.56	.82	1.57	.88	.13	13.13	-	-	44.49	2.03	8.17	.57	1.22

Country : DDR  
 Station : KAP ARKONA  
 Year : 1988

Sampler type : WET ONLY  
 Sampling period : WEEKLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S A-SO4S	NO2N T-NO3N T-NH4N	
JAN	82.3	.60	.50	2.34	.70	.20	-	-	-	-	2.00	9.80	4.50	3.90
FEB	42.0	.90	.90	2.42	2.20	.40	-	-	-	-	4.60	3.40	1.50	1.30
MAR	35.9	1.30	1.10	2.90	1.20	.30	-	-	-	-	2.20	4.30	2.50	1.00
APR	28.3	1.30	3.50	5.09	1.30	.30	-	-	-	-	3.30	2.90	1.50	1.70
MAY	33.1	1.00	1.30	3.07	.40	.10	-	-	-	-	1.00	1.60	1.50	1.40
JUN	31.8	.70	.70	1.66	.50	.10	-	-	-	-	.80	.80	2.20	1.20
JUL	95.0	.70	.60	1.65	.60	.10	-	-	-	-	1.10	1.30	2.30	1.30
AUG	28.4	1.10	1.70	2.32	1.00	.20	-	-	-	-	1.50	1.10	1.40	

**ANNEX 5**

Annual statistics on HELCOM/EGAP data 1989

DATA COVERAGE 1989		*	**	PRECIPITATION												AIR				
		mm	mm	NO <sub>3</sub>	NH <sub>4</sub>	SO <sub>4</sub>	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO <sub>2</sub>	SO <sub>4</sub>	NO <sub>2</sub>	TNx	TNy		
SF	HAILUOTO	12	BM	12	12	12	12	12	--	--	--	12	12	--	--	--	--	--		
SF	HAILUOTO	12	BW	12	12	12	12	12	12	12	12	12	12	--	--	--	--	--		
SF	VIROLAHTI	13	BD	12	12	12	12	12	--	--	--	--	--	--	--	12	11	11		
SF	VIROLAHTI	13	BM	12	12	12	12	12	12	12	12	12	12	--	--	--	--	--		
SF	UTØ	14	BD	12	11	11	11	11	11	11	11	11	11	--	--	--	11	6		
SF	HAAPASAARI	15	BW	12	12	12	12	12	12	12	12	12	12	--	--	--	--	--		
SF	TVÆRMINNE	16	BM	12	12	12	12	12	--	--	--	--	--	--	--	--	--	--		
SF	JOMALA	17	BM	12	12	12	12	12	--	--	--	--	--	--	--	--	--	--		
SF	RAJJA	18	BM	12	12	12	12	12	--	--	--	--	--	--	--	--	--	--		
SF	YLIMÄRKU	19	BM	12	12	12	12	12	--	--	--	--	--	--	--	--	--	--		
SF	SIPOO	20	BM	12	11	11	11	11	--	--	--	--	--	--	--	--	--	--		
SF	SULVA	21	BM	12	8	8	8	8	--	--	--	--	--	--	--	--	--	--		
SF	KORPPOO	22	BM	12	12	12	12	12	--	--	--	--	--	--	--	--	--	--		
SE	ARUP	31	WM	12	12	12	12	12	12	12	12	12	12	--	--	--	--	--		
SE	ASPVRETEN	32	WM	12	12	12	12	12	12	12	10	10	9	11	--	12	12	12		
SE	RICKLEÅ	33	BM	12	11	11	12	12	--	--	--	--	--	--	--	--	--	--		
SE	VÄVIHILL	34	WD	12	12	12	12	12	--	--	--	--	--	--	--	12	12	12		
SE	RØRVIK	35	WD	12	12	12	12	12	--	--	--	--	--	--	--	12	12	12		
SE	HOBURG	36	WD	12	11	11	11	11	--	--	--	--	--	--	--	12	12	12		
SU	NIDA	41	BD	6	5	4	6	6	--	--	--	--	--	--	--	9	11	12		
SU	SYRVE	42	BD	12	12	12	12	12	--	--	--	--	--	--	--	--	--	--		
SU	RUTSAVA	43	BD	12	12	12	12	12	--	--	--	--	--	--	--	12	11	11		
SU	LAHEMAA	44	BD	12	12	11	12	12	--	--	--	--	--	--	--	11	11	12		
PL	LEBA	51	BD	12	12	12	12	12	12	12	12	12	12	--	--	--	--	--		
DD	KAPARKONA	61	WW	12	12	12	12	12	--	--	--	--	--	--	--	12	12	12		
DE	DANISCH-NIENHOF	72	WW	12	12	12	12	12	--	--	--	--	--	--	--	--	--	--		
DK	KELDSNOR	81	WD	12	11	11	12	12	--	--	--	--	--	--	--	12	12	12		

Precipitation and air data reported to HELCOM.  
Number of monthly averages reported per station.

\*) Internal station nr.

\*\*) B - Bulk, W - Wet only

M - Monthly.

W - Weekly, D - Daily

TNx = HNO<sub>3</sub> + NO<sub>3</sub>-  
TNy = NH<sub>3</sub> + NH<sub>4</sub>+

Country : FINLAND  
Station : HAILUOTO  
Year : 1989

Sampler type : BULK  
Sampling period : MONTHLY

mm	NO <sub>3</sub> N	NH <sub>4</sub> N	SO <sub>4</sub> S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO <sub>2</sub> S	A-SO <sub>4</sub> S	NO <sub>2</sub> N	T-NO <sub>3</sub> N	T-NH <sub>4</sub> N	
JAN	57.2	.78	.48	.86	.63	.11	-	-	-	-	-	-	.90	-	-	-
FEB	46.1	.53	.29	.57	.41	.07	-	-	-	-	-	-	.40	-	-	-
MAR	59.1	.67	.37	1.07	.31	.04	-	-	-	-	-	-	.40	-	-	-
APR	19.2	.97	1.60	2.44	.67	.11	-	-	-	-	-	-	.40	-	-	-
MAY	52.9	.32	.11	.78	.29	.05	-	-	-	-	-	-	.20	-	-	-
JUN	25.3	.23	.04	.78	.24	.04	-	-	-	-	-	-	.20	-	-	-
JUL	45.1	.03	.01	.38	.26	.06	-	-	-	-	-	-	.30	-	-	-
AUG	71.8	.21	.07	.69	.14	.03	-	-	-	-	-	-	.20	-	-	-
SEP	18.7	.79	2.60	2.14	.74	.11	-	-	-	-	-	-	.20	-	-	-
OCT	39.3	.26	.21	.78	.25	.44	-	-	-	-	-	-	.80	-	-	-
NOV	54.6	.36	.31	.77	.38	.05	-	-	-	-	-	-	.30	-	-	-
DEC	16.3	.84	.82	1.41	1.08	.15	-	-	-	-	-	-	1.70	-	-	-
YEAR	505.6	.44	.38	.89	.38	.09	-	-	-	-	-	-	.43	-	-	-

Country : FINLAND  
Station : HAILUOTO  
Year : 1989

Sampler type : BULK  
Sampling period : WEEKLY

mm	NO <sub>3</sub> N	NH <sub>4</sub> N	SO <sub>4</sub> S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO <sub>2</sub> S	A-SO <sub>4</sub> S	NO <sub>2</sub> N	T-NO <sub>3</sub> N	T-NH <sub>4</sub> N	
JAN	31.0	.39	.07	.35	-	.04	2.90	.08	-	49.00	-	-	-	-	-	-
FEB	33.7	.43	.19	.50	-	.04	5.30	.10	-	172.00	-	-	-	-	-	-
MAR	41.6	.75	.38	1.05	-	.03	7.10	.15	-	97.00	-	-	-	-	-	-
APR	6.0	2.40	2.75	6.55	-	.26	29.50	.68	-	135.00	-	-	-	-	-	-
MAY	30.2	.34	.29	1.09	-	.04	7.30	.17	-	129.00	-	-	-	-	-	-
JUN	8.7	.56	.57	.56	-	.09	3.70	.11	-	19.00	-	-				

Country : FINLAND  
 Station : VIROLAHTI  
 Year : 1989

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N	T-NH4N
JAN	41.5	.91	.72	1.22	.95	.12	-	-	-	-	1.10	-	-	-
FEB	44.4	1.12	1.30	1.54	.76	.15	-	-	-	-	1.30	-	-	-
MAR	38.2	1.41	1.80	2.76	.49	.19	-	-	-	-	1.10	-	-	-
APR	28.4	.85	2.00	2.58	.25	.13	-	-	-	-	.40	-	-	-
MAY	36.2	.80	.85	2.17	.32	.19	-	-	-	-	.50	-	-	-
JUN	49.5	.31	.23	1.08	.22	.10	-	-	-	-	.20	-	-	-
JUL	66.9	.05	.09	1.08	.23	.10	-	-	-	-	.40	-	-	-
AUG	196.5	.36	.54	1.28	.20	.08	-	-	-	-	.30	-	-	-
SEP	24.0	.69	1.70	2.16	.43	.21	-	-	-	-	.80	-	-	-
OCT	80.6	.38	.23	1.06	.43	.17	-	-	-	-	.80	-	-	-
NOV	44.5	.82	1.30	2.35	.60	.13	-	-	-	-	.80	-	-	-
DEC	60.2	.76	.39	1.34	.69	.10	-	-	-	-	1.00	-	-	-
YEAR	710.9	.58	.71	1.52	.41	.12	-	-	-	-	.63	-	-	-

Country : FINLAND  
 Station : UTO  
 Year : 1989

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N	T-NH4N
JAN	19.0	1.29	.54	1.06	3.17	.33	-	-	-	-	5.44	-	-	-
FEB	31.3	1.34	.98	1.79	3.82	.55	-	-	-	-	7.14	-	-	-
MAR	45.7	1.19	.86	1.22	2.11	.26	-	-	-	-	4.11	-	-	-
APR	43.4	.72	1.38	2.27	.58	.12	-	-	-	-	1.06	-	-	-
MAY	25.1	1.14	1.38	2.76	1.77	.22	-	-	-	-	2.76	-	-	-
JUN	53.9	.39	.95	1.43	.52	.10	-	-	-	-	.85	-	-	-
JUL	77.7	.29	.52	1.03	.59	.11	-	-	-	-	.98	-	-	-
AUG	49.0	.73	.94	1.77	1.32	.16	-	-	-	-	2.38	-	-	-
SEP	16.8	.54	.30	.90	1.11	.12	-	-	-	-	1.82	-	-	-
OCT	55.5	.75	.47	1.02	1.71	.20	-	-	-	-	2.95	-	-	-
NOV	69.0	.60	.70	.94	2.22	.21	-	-	-	-	2.87	-	-	-
DEC	45.9	-	-	-	-	-	-	-	-	-	-	-	-	-
YEAR	532.3	.72	.81	1.40	1.54	.20	-	-	-	-	2.59	-	-	-

Country : FINLAND  
 Station : HAAPASAARI  
 Year : 1989

Sampler type : BULK  
 Sampling period : WEEKLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N	T-NH4N
JAN	30.5	.59	.32	.80	-	.10	6.50	.11	-	15.00	-	-	-	-
FEB	31.0	1.12	.83	1.46	-	.18	15.90	.28	-	24.00	-	-	-	-
MAR	27.7	1.59	1.35	2.92	-	.29	19.30	.62	-	90.00	-	-	-	-
APR	18.2	1.38	2.43	4.71	-	.34	67.50	.81	-	276.00	-	-	-	-
MAY	15.2	1.04	2.92	2.86	-	.25	8.90	.14	-	13.00	-	-	-	-
JUN	6.4	1.25	.55	1.29	-	.37	13.20	.16	-	20.00	-	-	-	-
JUL	35.5	.42	.56	1.51	-	.19	18.40	.06	-	54.00	-	-	-	-
AUG	69.7	.55	1.02	1.84	-	.10	49.20	.29	-	97.00	-	-	-	-
SEP	10.5	1.18	1.30	2.91	-	.24	14.00	.22	-	24.00	-	-	-	-
OCT	54.1	.55	.43	1.37	-	.14	8.40	.26	-	61.00	-	-	-	-
NOV	20.4	1.42	1.17	4.17	-	.32	20.30	.36	-	99.00	-	-	-	-
DEC	35.8	.74	.36	1.42	-	.14	6.00	.19	-	19.00	-	-	-	-
YEAR	355.0	.84	.93	2.00	-	.18	22.50	.28	-	67.53	-	-	-	-

Country : FINLAND

Station : TVARMINNE

Year : 1989

Sampler type : BULK

Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N	T-NH4N
JAN	39.3	.96	.49	1.08	1.46	.19	-	-	-	-	2.50	-	-	-
FEB	56.9	.79	.59	1.06	1.70	.23	-	-	-	-	2.70	-	-	-
MAR	45.1	1.27	.98	1.62	.99	.15	-	-	-	-	1.70	-	-	-
APR	41.9	.91	1.50	2.38	.25	.16	-	-	-	-	.50	-	-	-
MAY	28.4	1.20	.35	3.54	.67	.24	-	-	-	-	.80	-	-	-
JUN	30.9	.28	.14	1.08	.23	.07	-	-	-	-	.20	-	-	-
JUL	25.7	.15	.43	.96	.51	.17	-	-	-	-	.80	-	-	-
AUG	75.2	.03	.23	1.45	.55	.16	-	-	-	-	.80	-	-	-
SEP	19.8	.77	2.60	2.54	.71	.33	-	-	-	-	1.10	-	-	-
OCT	54.9	.86	.75	1.54	.76	.12	-	-	-	-	1.10	-	-	-
NOV	67.3	.78	1.20	1.83	.81	.11	-	-	-	-	1.10	-	-	-
DEC	68.5	.66	.35	.84	.76	.12	-	-	-	-	1.30	-	-	-
YEAR	553.9	.70	.72	1.55	.82	.16	-	-	-	-	1.27	-	-	-

Country : FINLAND  
 Station : YLIMARKU  
 Year : 1989

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	45.6	.64	.72	.94	.67	.08	-	-	-	-	1.10	-	-
FEB	56.3	.70	.79	1.26	.53	.12	-	-	-	-	.70	-	-
MAR	65.2	1.04	1.05	1.66	.42	.06	-	-	-	-	.70	-	-
APR	17.1	1.00	1.90	2.86	.44	.12	-	-	-	-	.50	-	-
MAY	43.5	.48	1.40	2.07	.41	.17	-	-	-	-	.30	-	-
JUN	35.8	.28	.40	1.18	.23	.10	-	-	-	-	.20	-	-
JUL	88.2	.09	.08	.29	.16	.04	-	-	-	-	.40	-	-
AUG	61.8	.33	.91	1.48	.25	.06	-	-	-	-	.50	-	-
SEP	33.6	.49	2.32	2.07	.36	.09	-	-	-	-	.30	-	-
OCT	52.8	.44	1.10	1.28	.21	.06	-	-	-	-	.50	-	-
NOV	58.6	.51	.80	1.03	.79	.06	-	-	-	-	.240	-	-
DEC	26.2	.83	1.50	1.29	1.36	.19	-	-	-	-	-	-	-
YEAR	584.7	.52	.92	1.29	.44	.08	-	-	-	-	.55	-	-

Country : FINLAND  
 Station : SIPOO  
 Year : 1989

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	32.1	.67	.36	.94	.68	.11	-	-	-	-	1.20	-	-
FEB	88.8	.67	.80	1.45	.56	.13	-	-	-	-	.80	-	-
MAR	65.1	-	-	-	-	-	-	-	-	-	-	-	-
APR	44.4	.64	1.30	1.98	.25	.12	-	-	-	-	.40	-	-
MAY	26.2	.85	1.20	2.86	.48	.32	-	-	-	-	.70	-	-
JUN	26.8	.44	.62	1.38	.24	.07	-	-	-	-	.20	-	-
JUL	82.1	.07	.11	.78	.23	.10	-	-	-	-	.30	-	-
AUG	119.4	.30	.18	.89	.14	.08	-	-	-	-	.20	-	-
SEP	30.5	.53	.55	1.49	.15	.22	-	-	-	-	.80	-	-
OCT	51.4	.37	.22	1.14	.71	.14	-	-	-	-	.90	-	-
NOV	44.2	.71	.78	1.44	.77	.13	-	-	-	-	.80	-	-
DEC	60.7	.73	.48	.95	.65	.11	-	-	-	-	1.20	-	-
YEAR	671.7	.49	.51	1.24	.42	.12	-	-	-	-	.62	-	-

Country : FINLAND  
 Station : SULVA  
 Year : 1989

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	32.2	-	-	-	-	-	-	-	-	-	-	-	-
FEB	56.8	-	-	-	-	-	-	-	-	-	-	-	-
MAR	55.1	-	-	-	-	-	-	-	-	-	-	-	-
APR	23.3	-	-	-	-	-	-	-	-	-	-	-	-
MAY	45.5	.30	.58	1.14	.76	.32	-	-	-	-	1.40	-	-
JUN	14.6	.01	.35	.37	.33	.12	-	-	-	-	.70	-	-
JUL	23.4	.11	.10	.28	.25	.10	-	-	-	-	.30	-	-
AUG	90.2	.03	.29	.48	.23	.11	-	-	-	-	.40	-	-
SEP	14.7	.67	1.00	1.44	.72	.44	-	-	-	-	1.80	-	-
OCT	50.2	.37	.77	.77	.30	.05	-	-	-	-	.50	-	-
NOV	63.0	.48	.84	.85	.61	.09	-	-	-	-	.70	-	-
DEC	22.9	1.16	2.40	2.11	2.30	.36	-	-	-	-	4.70	-	-
YEAR	491.9	.32	.68	.83	.56	.16	-	-	-	-	.99	-	-

Country : FINLAND

Station : KORPPOO

Sampler type : BULK

Year : 1989

Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	19.0	.90	.52	1.02	.99	.12	-	-	-	-	1.50	-	-
FEB	31.3	.93	.98	1.59	1.30	.19	-	-	-	-	2.20	-	-
MAR	45.7	1.55	1.50	.53	.86	.13	-	-	-	-	1.70	-	-
APR	43.4	.71	1.40	1.98	.23	.12	-	-	-	-	.30	-	-
MAY	25.1	.76	1.20	1.95	.61	.18	-	-	-	-	.50	-	-
JUN	53.9	.27	.45	1.19	.17	.05	-	-	-	-	.10	-	-
JUL	77.7	.40	.29	1.47	.31	.08	-	-	-	-	.40	-	-
AUG	49.0	.55	.51	1.46	.51	.10	-	-	-	-	.90	-	-
SEP	16.8	.38	.80	.96	.45	.06	-	-	-	-	.60	-	-
OCT	55.5	.54	.50	.85	.59	.08	-	-	-	-	.90	-	-
NOV	69.0	.53	.30	1.25	.59	.06	-	-	-	-	.70	-	-
DEC	45.9	.50	.29	.61	1.05	.12	-	-	-	-	1.70	-	-
YEAR	532.3	.63	.65	1.23	.59	.10	-	-	-	-	.88	-	-

Country : SWEDEN

Station : ARUP

Sampler type : WET ONLY

Year : 1989

Sampling period : MONTHLY

	mm	NO3N	NH
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Country : SWEDEN  
 Station : RICKLEÅ  
 Year : 1989

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	22.0	.22	.07	.25	.34	.05	-	-	-	.60	-	-	-
FEB	55.0	.46	.45	.78	.32	.05	-	-	-	.53	-	-	-
MAR	50.0	.58	.53	1.00	.21	.03	-	-	-	.38	-	-	-
APR	42.0	.88	1.76	2.91	.28	.10	-	-	-	.47	-	-	-
MAY	51.0	.20	.24	.65	.09	.05	-	-	-	.18	-	-	-
JUN	51.0	.36	.57	1.04	.12	.06	-	-	-	.22	-	-	-
JUL	11.0	-	-	.66	.14	.03	-	-	-	.28	-	-	-
AUG	76.0	.20	.23	.54	.15	.02	-	-	-	.31	-	-	-
SEP	25.0	.57	1.10	1.86	.14	.05	-	-	-	.36	-	-	-
OCT	48.0	.27	.26	.51	.18	.03	-	-	-	.35	-	-	-
NOV	73.0	.33	.33	.76	.21	.03	-	-	-	.32	-	-	-
DEC	28.0	.43	.20	.56	.56	.07	-	-	-	.98	-	-	-
YEAR	532.0	.39	.49	.94	.21	.04	-	-	-	.38	-	-	-

Country : SWEDEN  
 Station : VAVIHILL  
 Year : 1989

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	20.1	1.69	1.95	2.09	3.31	.41	-	-	-	5.10	-	-	5.70 1.19 2.65
FEB	43.6	1.57	1.60	1.75	2.94	.35	-	-	-	4.90	-	-	4.20 1.37 2.45
MAR	90.4	1.13	1.18	1.27	2.41	.26	-	-	-	4.00	-	-	2.80 1.43 2.56
APR	33.4	1.32	1.72	2.57	.31	.09	-	-	-	.70	-	-	1.30 .99 2.86
MAY	21.3	1.46	3.99	2.66	1.84	.26	-	-	-	3.20	-	-	1.20 .78 2.04
JUN	55.2	.91	1.65	1.89	.44	.08	-	-	-	.90	-	-	1.10 .53 1.94
JUL	123.3	.40	.91	.97	1.12	.15	-	-	-	2.00	-	-	1.30 .41 1.98
AUG	125.9	.42	.66	.80	.47	.06	-	-	-	.80	-	-	1.70 .76 1.99
SEP	53.5	.80	1.06	1.37	.44	.07	-	-	-	.90	-	-	1.70 .79 2.25
OCT	114.1	.74	.92	.95	1.17	.16	-	-	-	2.20	-	-	2.80 1.00 1.99
NOV	38.9	.86	.91	1.24	1.61	.21	-	-	-	2.50	-	-	3.60 1.09 1.37
DEC	45.6	.85	.76	.99	2.56	.31	-	-	-	4.10	-	-	4.10 .76 1.73
YEAR	765.3	.83	1.14	1.27	1.33	.17	-	-	-	2.29	-	-	2.62 .93 2.15

Country : SWEDEN  
 Station : RORVIK  
 Year : 1989

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	7.3	2.04	2.33	2.54	9.10	1.03	-	-	-	15.40	-	-	4.10 .80 1.61
FEB	53.8	1.24	.95	1.18	7.71	.86	-	-	-	12.80	-	-	2.50 .62 1.24
MAR	71.5	.90	.73	.94	4.44	.47	-	-	-	7.30	-	-	2.20 .76 1.65
APR	34.5	1.27	1.48	2.77	.58	.07	-	-	-	1.40	-	-	1.70 .70 1.78
MAY	27.6	1.08	1.10	1.82	2.11	.18	-	-	-	4.00	-	-	1.40 .65 1.01
JUN	18.4	1.40	.87	1.64	1.65	.32	-	-	-	6.70	-	-	1.20 .39 1.24
JUL	94.6	.52	.66	1.01	3.13	.34	-	-	-	5.00	-	-	1.50 .39 .99
AUG	52.3	.88	.47	1.06	1.89	.23	-	-	-	3.30	-	-	1.20 .55 1.10
SEP	45.1	.62	.69	1.11	.85	.11	-	-	-	2.50	-	-	1.40 .46 .89
OCT	112.2	.46	.31	.54	2.07	.24	-	-	-	3.60	-	-	2.10 .75 1.23
NOV	18.7	1.20	.83	1.36	3.57	.44	-	-	-	5.80	-	-	4.20 .71 1.11
DEC	54.5	.46	.28	.44	1.95	.22	-	-	-	3.20	-	-	3.10 .48 .83
YEAR	590.5	.79	.68	1.08	2.96	.33	-	-	-	5.17	-	-	2.22 .61 1.22

Country : SWEDEN  
 Station : HOBURG  
 Year : 1989

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S A-SO4S	NO2N T-NO3N T-NH4N
JAN	7.4	2.27	1.43	2.14	5.98	.76	-	-	-	7.70	-	-	3.20
FEB	29.7	2.51	1.23	1.85	8.59	.95	-	-	-	10.60	-	-	2.20
MAR	36.8	1.54	.99	1.37	2.70	.35	-	-	-	4.20	-	-	1.40
APR	6.1	1.58	2.02	5.14	1.22	.31	-	-	-	1.90	-	-	1.10
MAY	26.0	-	-	-	-	-	-	-	-	-	-	-	.90
JUN	53.8	.21	1.34	1.14	.25	.05	-	-	-	.40	-	-	1.00
JUL	6.8	.60	2.31	.66	.63	.12	-	-	-	1.70	-	-	.90
AUG	25.4	1.05	2.39	1.94	1.95	.34	-	-	-	2.70	-	-	.50
SEP	13.4	2.00	2.82	3.47	1.83	.37	-	-	-	3.30	-	-	.60
OCT	71.9	.93	.74	1.24	1.90	.24	-	-	-	2.80	-	-	.90
NOV	52.8	.89	.91	1.40	1.56	.21	-	-	-	2.90	-	-	1.00
DEC	22.8	.99	.60	.96	4.23	.53	-	-	-	7.50	-	-	1.10
YEAR	352.9	1.11	1.21	1.53	2.49	.32	-	-	-	3.70	-	-	1.23

\*) Reporting NH4+

Country : USSR  
 Station : NIDA

Country : USSR  
 Station : RUTSAVA  
 Year : 1989

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N T-NO3N T-NH4N*
JAN	21.2	1.80	1.00	1.27	3.90	-	-	-	-	-	-	1.80	.30	.90
FEB	39.3	1.80	.80	1.11	2.30	-	-	-	-	-	-	2.90	.40	.90
MAR	56.3	1.40	.60	1.42	2.10	-	-	-	-	-	-	1.90	.40	1.40
APR	43.7	.60	.50	1.47	.30	-	-	-	-	-	-	.20	.10	.40
MAY	15.9	2.60	3.10	3.24	.70	-	-	-	-	-	-	.30	-	-
JUN	85.9	.30	.20	1.26	.50	-	-	-	-	-	-	.40	.10	.20
JUL	47.4	.20	1.00	1.93	.80	-	-	-	-	-	-	1.90	.30	.40
AUG	111.9	.10	11.50	.39	1.30	-	-	-	-	-	-	1.30	.20	.40
SEP	33.3	.20	.20	1.02	1.00	-	-	-	-	-	-	.20	.10	.50
OCT	131.8	.50	.30	.82	1.00	-	-	-	-	-	-	.80	.20	.80
NOV	55.7	.70	.30	1.21	1.10	-	-	-	-	-	-	.70	.20	.70
DEC	76.5	.20	.20	.56	1.70	-	-	-	-	-	-	-	-	-
YEAR	718.9	.60	2.21	1.06	1.25	-	-	-	-	-	-	1.22	.23	.66

\*) Reporting NH4+

Country : USSR  
 Station : LAHEMAA  
 Year : 1989

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N T-NO3N T-NH4N*
JAN	33.2	.30	.20	.11	.60	-	-	-	-	-	-	.90	.10	.30
FEB	42.1	.60	.30	.40	1.00	-	-	-	-	-	-	.60	.10	.60
MAR	32.6	.60	.40	1.01	.60	-	-	-	-	-	-	.50	.10	.70
APR	26.2	.50	.50	2.16	.50	-	-	-	-	-	-	1.10	.10	.30
MAY	18.7	.60	.30	2.06	.40	-	-	-	-	-	-	.70	-	.30
JUN	50.6	.20	.20	1.07	.40	-	-	-	-	-	-	.60	.10	.10
JUL	69.9	.10	-.92	.50	-	-	-	-	-	-	-	-.10	.20	-
AUG	132.8	.20	.30	1.05	.20	-	-	-	-	-	-	-.50	.10	.40
SEP	29.3	.40	.30	1.60	1.00	-	-	-	-	-	-	.60	.10	.20
OCT	94.5	.20	1.10	<.37	6.90	-	-	-	-	-	-	1.00	2.00	.40
NOV	45.5	.40	2.20	.30	.70	-	-	-	-	-	-	.30	.30	.50
DEC	37.9	.40	.20	.38	.80	-	-	-	-	-	-	-.30	.30	.50
YEAR	613.3	.30	.59	.93	1.51	-	-	-	-	-	-	.65	.29	.36

\*) Reporting NH4+

Country : POLAND  
 Station : LEBA  
 Year : 1989

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N T-NO3N T-NH4N
JAN	15.6	.77	.60	1.40	1.23	.14	19.80	3.14	-	51.00	3.19	-	-	-
FEB	30.1	.75	.49	2.84	.91	.13	24.30	2.91	-	41.00	1.81	-	-	-
MAR	37.8	.72	.68	1.30	.78	.10	16.10	1.60	-	29.00	1.45	-	-	-
APR	26.9	.82	.94	2.24	.59	.13	18.90	8.43	-	42.00	1.17	-	-	-
MAY	17.2	.61	.88	1.59	.20	.07	15.80	5.43	-	36.00	.39	-	-	-
JUN	41.0	.38	.64	1.48	.33	.08	15.00	9.73	-	27.90	.62	-	-	-
JUL	71.5	.29	.98	1.73	1.02	.13	24.40	8.60	-	30.00	1.58	-	-	-
AUG	50.6	.29	.62	.85	1.19	.14	15.40	8.11	-	19.00	1.89	-	-	-
SEP	28.7	.61	1.39	1.85	.92	.13	20.30	12.38	-	21.00	1.87	-	-	-
OCT	86.3	.45	.63	.41	1.35	.17	3.50	3.30	-	10.00	2.03	-	-	-
NOV	34.1	.52	.99	1.09	2.08	.26	12.50	9.67	-	56.00	3.21	-	-	-
DEC	72.8	.51	.39	1.51	1.05	.14	6.50	3.80	-	24.00	1.77	-	-	-
YEAR	512.6	.50	.73	1.38	1.04	.14	14.34	6.22	-	27.79	1.75	-	-	-

Country : DDR  
 Station : KAP ARKONA  
 Year : 1989

Sampler type : WET ONLY  
 Sampling period : WEEKLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N T-NO3N T-NH4N
JAN	12.0	1.20	1.00	2.24	1.90	.40	-	-	-	-	-	3.20	5.20	2.40
FEB	18.3	1.50	1.30	3.28	2.60	.50	-	-	-	-	-	4.60	3.20	3.70
MAR	42.0	1.20	1.50	2.09	2.50	.40	-	-	-	-	-	4.20	3.00	2.80
APR	21.9	1.30	2.00	4.51	21.40	2.70	-	-	-	-	-	39.30	2.40	2.10
MAY	9.3	2.40	3.20	3.07	1.50	.30	-	-	-	-	-	2.90	1.00	1.20
JUN	52.8	.90	1.30	2.15	.60	.10	-	-	-	-	-	1.20	.50	2.20
JUL	32.5	.50	1.00	1.59	1.30	.30	-	-	-	-	-	2.90	.60	1.50
AUG	112.9	.40	.60	1.22	2.20	.40	-	-	-	-	-	5.90	.80	1.10
SEP	18.6	.90	1.10	1.96	1.70	.30	-	-	-	-	-	3.90	.80	2.60
OCT	58.8	.60	.60	1.01	1.10	.20	-	-	-	-	-	1.80	2.40	2.00
NOV	30.5	.90	.70	1.89	1.30	.20	-	-	-	-	-	2.5		

**ANNEX 6**

Annual statistics on HELCOM/EGAP data 1990

DATA COVERAGE 1990		*	**	PRECIPITATION												AIR					
		mm	mm	NOS	NH4	SO4	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2	SO4	NO2	TNx	TNy			
SF	HAILUOTO	12	BM	12	12	12	11	-	-	-	-	12	12	-	-	-	-	-	-	-	
SF	HAILUOTO	12	BW	11	11	11	11	-	11	11	-	11	11	-	-	-	-	-	-	-	
SF	VIROLAHTI	13	BD	12	12	12	12	12	-	-	-	-	-	-	-	-	12	12	12		
SF	VIROLAHTI	13	BM	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SF	UTØ	14	BD	12	12	12	12	12	-	-	-	-	-	-	-	-	10	12	12		
SF	HAAPASAARI	15	BW	12	11	11	-	11	-	-	-	-	-	-	-	-	-	-	-	-	
SF	TVÆRMINNE	16	BM	12	12	12	10	10	-	-	-	-	-	-	-	-	-	-	-	-	
SF	JOMALA	17	BM	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SF	RAHJA	18	BM	12	12	12	10	10	-	-	-	-	-	-	-	-	-	-	-	-	
SF	YLIMÄRKU	19	BM	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SF	SIPOC	20	BM	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SF	SULVA	21	BM	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SF	KORPOO	22	BM	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SE	ARUP	31	BN	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SE	ASPVRÄTEN	32	WM	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SE	RICKLEÅ	33	BM	11	11	11	11	11	-	-	-	-	-	-	-	-	-	-	-	-	
SE	VAVIHILL	34	WD	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SE	RØRVIK	35	WD	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SE	HOBURG	36	WD	12	12	12	12	12	-	-	-	-	-	-	-	-	-	-	-	-	
SU	NIDA	41	BD	11	10	10	10	10	-	-	-	-	-	-	-	-	12	12	12		
SU	SYRVE	42	BD	10	10	10	10	10	-	-	-	-	-	-	-	-	-	-	-	-	
SU	RUTSAYA	43	BD	12	12	12	12	12	-	-	-	-	-	-	-	-	12	12	12		
SU	LAHEMÄÄ	44	BD	12	12	9	12	12	-	-	-	-	-	-	-	-	12	12	12		
PL	LEBA	51	BD	12	12	12	12	12	-	-	-	-	-	-	-	-	12	12	12		
DD	KAPARKONA	61	WW	12	12	12	12	12	-	-	-	-	-	-	-	-	12	12	12		
DE	DANISCH-NIENHOF	72	WW	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2		
DK	KELDSNOR	81	WD	12	12	12	12	12	-	-	-	-	-	-	-	-	12	12	12		

Precipitation and air data reported to HELCOM.  
Number of monthly averages reported per station.

\*) Internal station nr.

\*\*) B - Bulk, W - Wet only

M - Monthly, W - Weekly, D - Daily

TNx = HNO3 + NO3-  
TNy = NH3 + NH4+

Country : FINLAND  
Station : HAILUOTO  
Year : 1990

Sampler type : BULK  
Sampling period : MONTHLY

mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	16.6	.98	.71	1.19	.08	.08	-	-	-	-	.90	-	-	-	-
FEB	46.5	.58	.35	.97	.38	.08	-	-	-	-	.50	-	-	-	-
MAR	31.7	.68	.49	1.13	.79	.14	-	-	-	-	1.20	-	-	-	-
APR	4.5	1.10	1.30	2.30	-	-	-	-	-	-	.70	-	-	-	-
MAY	7.4	.45	.74	1.15	.59	.15	-	-	-	-	.60	-	-	-	-
JUN	42.7	.47	.65	2.16	.43	.44	-	-	-	-	.50	-	-	-	-
JUL	68.2	.15	.20	.48	.20	.05	-	-	-	-	.30	-	-	-	-
AUG	59.8	.15	.31	.58	.19	.02	-	-	-	-	.10	-	-	-	-
SEP	16.8	.27	.67	.97	.41	.07	-	-	-	-	.40	-	-	-	-
OCT	25.0	.62	.91	1.76	.47	.09	-	-	-	-	.50	-	-	-	-
NOV	24.6	.37	.18	.35	.61	.06	-	-	-	-	.80	-	-	-	-
DEC	34.4	.58	.35	.74	.66	.09	-	-	-	-	.90	-	-	-	-
YEAR	378.2	.43	.44	.99	.40	.11	-	-	-	-	.53	-	-	-	-

Country : FINLAND  
Station : HAILUOTO  
Year : 1990

Sampler type : BULK  
Sampling period : WEEKLY

mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	27.7	.55	.19	.35	-	.16	77.10	.10	-	22.20	-	-	-	-	-
FEB	35.9	.59	.26	.61	-	.04	7.00	.20	-	141.60	-	-	-	-	-
MAR	15.3	.58	.30	.76	-	.10	7.80	.12	-	38.80	-	-	-	-	-
APR	1.1	1.23	1.17	2.83	-	.37	48.80	.64	-	85.90	-	-	-	-	-
MAY	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JUN	5.4	.29	.23	.99	-	.08	3.60	.06	-	12.70	-	-	-	-	-
JUL	31.1	.33	.36	.98	-	.06	2.90	.08	-	14.60	-	-	-	-	-
AUG	23.9	.48	.65	1.27	-	.06	3.70	.08	-	14.30</					

Country : FINLAND  
 Station : VIROLAHTI  
 Year : 1990

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	98.7	.61	.56	1.15	.60	.12	-	-	-	-	1.10	-	-	-	-	-
FEB	140.0	.72	.73	1.37	.36	.11	-	-	-	-	.70	-	-	-	-	-
MAR	65.8	.71	.85	1.05	.54	.12	-	-	-	-	1.00	-	-	-	-	-
APR	13.4	1.31	2.10	2.85	.56	.20	-	-	-	-	1.00	-	-	-	-	-
MAY	47.3	.47	.56	1.29	.17	.15	-	-	-	-	.50	-	-	-	-	-
JUN	31.4	.27	.29	1.95	.58	.26	-	-	-	-	.80	-	-	-	-	-
JUL	139.8	.07	.28	.48	.21	.06	-	-	-	-	.30	-	-	-	-	-
AUG	70.5	.12	.04	.74	.68	.09	-	-	-	-	.50	-	-	-	-	-
SEP	62.9	.16	.14	.88	.29	.06	-	-	-	-	.40	-	-	-	-	-
OCT	53.8	.61	.71	.16	.48	.25	-	-	-	-	1.10	-	-	-	-	-
NOV	58.0	.36	.34	.77	.36	.07	-	-	-	-	.50	-	-	-	-	-
DEC	67.4	.76	.61	1.28	1.39	.91	-	-	-	-	.90	-	-	-	-	-
YEAR	849.0	.46	.50	1.00	.49	.18	-	-	-	-	.69	-	-	-	-	-

Country : FINLAND  
 Station : UTO  
 Year : 1990

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	67.2	.75	.27	.59	2.33	.32	-	-	-	-	5.31	-	-	2.20	.52	.43
FEB	76.1	.95	.69	.79	2.95	.29	-	-	-	-	5.04	-	-	1.70	.94	1.05
MAR	35.7	.77	.82	.53	4.74	.46	-	-	-	-	7.55	-	-	1.40	.65	.83
APR	17.6	.98	1.02	1.35	1.41	.17	-	-	-	-	2.50	-	-	-.62	1.03	
MAY	5.2	.94	3.46	1.89	3.02	.21	-	-	-	-	4.78	-	-	.25	.50	
JUN	14.6	1.44	2.06	3.62	.87	.22	-	-	-	-	1.76	-	-	1.80	.36	.90
JUL	43.6	.52	.59	1.06	1.89	.23	-	-	-	-	2.62	-	-	1.70	.25	.59
AUG	82.9	.45	.88	.83	.82	.10	-	-	-	-	1.04	-	-	1.30	.33	.83
SEP	117.2	.39	.29	.70	1.13	.14	-	-	-	-	1.87	-	-	1.30	.17	.34
OCT	65.4	.52	.46	.67	1.33	.16	-	-	-	-	2.12	-	-	1.80	.43	.70
NOV	51.8	.64	.24	.57	1.44	.16	-	-	-	-	2.96	-	-	2.10	.16	.21
DEC	42.8	1.83	.70	1.86	7.36	1.16	-	-	-	-	16.21	-	-	2.70	.34	.43
YEAR	620.1	.72	.60	.90	2.20	.27	-	-	-	-	4.05	-	-	1.80	.42	.65

Country : FINLAND  
 Station : HAAPASAARI  
 Year : 1990

Sampler type : BULK  
 Sampling period : WEEKLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	47.2	.60	.32	1.00	-	.15	4.60	.15	-	11.10	-	-	-	-	-	-
FEB	77.4	.64	.46	1.01	-	.08	6.50	.11	-	12.70	-	-	-	-	-	-
MAR	17.3	1.23	.89	.73	-	.26	8.20	.12	-	18.50	-	-	-	-	-	-
APR	3.2	4.44	3.91	8.13	-	.95	28.30	.47	-	68.80	-	-	-	-	-	-
MAY	7.0	1.98	1.70	4.83	-	.46	17.00	.19	-	60.90	-	-	-	-	-	-
JUN	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JUL	54.9	.27	.35	.99	-	.10	11.90	.07	-	61.10	-	-	-	-	-	-
AUG	35.7	.35	.93	1.29	-	.13	8.60	.07	-	18.40	-	-	-	-	-	-
SEP	13.1	.64	2.12	2.55	-	.38	37.70	.30	-	219.30	-	-	-	-	-	-
OCT	34.8	.99	4.07	2.43	-	.25	13.90	.18	-	47.00	-	-	-	-	-	-
NOV	31.2	.73	.26	1.13	-	.11	4.40	.07	-	10.50	-	-	-	-	-	-
DEC	29.2	1.30	.55	1.61	-	.20	11.70	.12	-	22.30	-	-	-	-	-	-
YEAR	354.6	.74	.96	1.42	-	.16	9.94	.12	-	34.11	-	-	-	-	-	-

Country : FINLAND

Station : TVÄRMINNE  
 Year : 1990

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	114.4	.58	.23	.64	1.90	.21	-	-	-	-	2.80	-	-	-	-	-
FEB	138.2	.70	.48	.92	.97	.14	-	-	-	-	1.70	-	-	-	-	-
MAR	67.1	.72	.71	1.00	1.24	.19	-	-	-	-	2.10	-	-	-	-	-
APR	17.3	1.23	1.40	2.21	1.03	.21	-	-	-	-	1.60	-	-	-	-	-
MAY	8.7	1.10	1.50	3.00	-	-	-	-	-	-	1.60	-	-	-	-	-
JUN	21.4	.70	.50	2.46	.43	.11	-	-	-	-	.50	-	-	-	-	-
JUL	87.7	.19	.51	.68	.21	.06	-	-	-	-	.40	-	-	-	-	-
AUG	66.5	.37	.20	.96	.42	.07	-	-	-	-	.30	-	-	-	-	-
SEP	63.3	.34	.28	.96</td												

Country : FINLAND  
 Station : YLIMARKKU  
 Year : 1990

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	44.3	.53	.50	.57	.41	.06	-	-	-	-	.60	-	-	-	-	-
FEB	59.3	.78	.81	1.06	.48	.03	-	-	-	-	.80	-	-	-	-	-
MAR	41.4	.32	.49	1.07	.35	.07	-	-	-	-	.50	-	-	-	-	-
APR	17.8	1.29	2.60	3.36	.43	.23	-	-	-	-	.60	-	-	-	-	-
MAY	20.8	.25	.74	1.27	.31	.07	-	-	-	-	.20	-	-	-	-	-
JUN	44.8	.21	3.70	1.47	.35	.33	-	-	-	-	.70	-	-	-	-	-
JUL	84.2	.15	.12	.59	.12	.05	-	-	-	-	.10	-	-	-	-	-
AUG	63.9	.32	.33	.77	.35	.04	-	-	-	-	.50	-	-	-	-	-
SEP	29.8	.40	1.10	1.58	.28	.06	-	-	-	-	.30	-	-	-	-	-
OCT	41.4	.75	1.58	1.86	.48	.15	-	-	-	-	.70	-	-	-	-	-
NOV	45.0	.32	.75	.56	.48	.06	-	-	-	-	.80	-	-	-	-	-
DEC	67.2	.61	.81	1.04	.75	.07	-	-	-	-	1.00	-	-	-	-	-
YEAR	559.9	.45	.96	1.08	.40	.09	-	-	-	-	.58	-	-	-	-	-

Country : FINLAND  
 Station : SIPOO  
 Year : 1990

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	112.9	.62	.43	.84	.68	.11	-	-	-	-	1.20	-	-	-	-	-
FEB	116.3	.47	.39	.78	.27	.08	-	-	-	-	.50	-	-	-	-	-
MAR	62.2	.74	.75	.94	.67	.12	-	-	-	-	1.20	-	-	-	-	-
APR	15.1	1.13	1.90	2.03	.83	.16	-	-	-	-	1.40	-	-	-	-	-
MAY	33.3	.60	.38	1.06	.46	.27	-	-	-	-	.70	-	-	-	-	-
JUN	42.9	.19	.18	.86	.43	.09	-	-	-	-	.20	-	-	-	-	-
JUL	105.3	.16	.01	.69	.12	.06	-	-	-	-	.10	-	-	-	-	-
AUG	25.6	.24	.09	1.16	.49	.14	-	-	-	-	.70	-	-	-	-	-
SEP	82.1	.29	.17	.76	.48	.11	-	-	-	-	.50	-	-	-	-	-
OCT	90.6	.41	.31	1.07	.38	.11	-	-	-	-	.60	-	-	-	-	-
NOV	46.2	.35	.17	.57	.38	.05	-	-	-	-	.40	-	-	-	-	-
DEC	24.4	.86	.69	1.36	1.67	.18	-	-	-	-	2.70	-	-	-	-	-
YEAR	756.9	.45	.34	.88	.47	.11	-	-	-	-	.70	-	-	-	-	-

Country : FINLAND  
 Station : SULVA  
 Year : 1990

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	54.8	.69	.19	.26	.53	.08	-	-	-	-	1.00	-	-	-	-	-
FEB	49.0	1.24	1.40	1.33	.82	.18	-	-	-	-	1.40	-	-	-	-	-
MAR	31.4	.42	.57	.52	.94	.17	-	-	-	-	1.90	-	-	-	-	-
APR	23.2	1.04	2.00	1.76	.47	.15	-	-	-	-	.70	-	-	-	-	-
MAY	11.8	.58	.81	.95	.63	.25	-	-	-	-	1.60	-	-	-	-	-
JUN	47.2	.16	.29	.57	.38	.10	-	-	-	-	.40	-	-	-	-	-
JUL	135.7	.14	.15	.38	.21	.05	-	-	-	-	.30	-	-	-	-	-
AUG	74.0	.29	.09	.68	.26	.06	-	-	-	-	.30	-	-	-	-	-
SEP	22.5	.35	1.20	.77	.31	.13	-	-	-	-	.50	-	-	-	-	-
OCT	26.4	.43	.66	.97	.32	.12	-	-	-	-	.70	-	-	-	-	-
NOV	40.0	.43	1.48	.65	.55	.05	-	-	-	-	.90	-	-	-	-	-
DEC	42.6	1.07	2.02	1.40	1.21	.16	-	-	-	-	2.10	-	-	-	-	-
YEAR	558.6	.49	.69	.73	.49	.10	-	-	-	-	.81	-	-	-	-	-

Country : FINLAND  
 Station : KORPPOO  
 Year : 1990

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	133.6	.62	.33	.73	.86	.04	-	-	-	-	1.20	-	-	-	-	-
FEB	66.8	.87	.67	1.25	.60	.10	-	-	-	-	1.00	-	-	-	-	-
MAR	49.4	.43	.35	.55	.56	.09	-	-	-	-	.90	-	-	-	-	-
APR	34.6	1.00	1.30	1.87	.40	.14	-	-	-	-	.60	-	-	-	-	-
MAY	9.5	.71	.66	1.76	.51	.20	-	-	-	-	.60	-	-	-	-	-
JUN	21.3	.59	4.00	3.05	.64	.13	-	-	-	-	2.70	-	-	-	-	-
JUL	61.7	.21	.16	.56	.48	.08	-	-	-	-	.20	-	-	-	-	-
AUG	96.2	.37	.15	.86	.44	.05	-	-	-	-	.30	-	-	-	-	-
SEP	122.9	.22	.09	.55	.60	.08	-	-	-	-	.80	-	-	-	-	-
OCT	95.2	.35	.38	.76	.47	.09	-	-	-	-	.70	-	-	-	-	-
NOV	35.9	.33	.14	.67	.39	.05										

Country : SWEDEN  
 Station : RICKLEA  
 Year : 1990

Sampler type : BULK  
 Sampling period : MONTHLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	107.0	.36	.15	.44	.34	.04	-	-	-	-	.60	-	-	-	-	-
FEB	78.0	.63	.52	.91	.31	.04	-	-	-	-	.58	-	-	-	-	-
MAR	28.0	.18	.09	.25	.28	.05	-	-	-	-	.45	-	-	-	-	-
APR	30.0	.63	.77	1.69	.32	.09	-	-	-	-	.44	-	-	-	-	-
MAY	29.0	.09	.03	.42	.08	.02	-	-	-	-	.04	-	-	-	-	-
JUN	27.0	.24	.60	1.14	.07	.07	-	-	-	-	.11	-	-	-	-	-
JUL	48.0	.13	.03	.57	.12	.02	-	-	-	-	.18	-	-	-	-	-
AUG	71.0	.25	.31	.64	.09	.02	-	-	-	-	.05	-	-	-	-	-
SEP	63.0	.14	.16	.39	.23	.03	-	-	-	-	.45	-	-	-	-	-
OCT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NOV	28.0	.34	.22	.62	.24	.03	-	-	-	-	.50	-	-	-	-	-
DEC	38.0	.44	.45	.88	.54	.06	-	-	-	-	.95	-	-	-	-	-
YEAR	547.0	.33	.28	.67	.25	.04	-	-	-	-	.42	-	-	-	-	-

Country : SWEDEN  
 Station : VAVIHILL  
 Year : 1990

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	86.3	1.03	1.33	1.68	4.33	.47	-	-	-	-	6.90	-	-	4.60	.90	1.85
FEB	71.3	.73	.75	.91	3.30	.39	-	-	-	-	5.40	-	-	4.50	1.45	2.20
MAR	39.5	.71	.91	1.17	3.71	.48	-	-	-	-	6.80	-	-	2.00	1.28	2.55
APR	54.2	.92	1.61	1.45	1.52	.25	-	-	-	-	3.30	-	-	1.60	1.01	2.19
MAY	50.5	.59	3.14	1.49	1.29	.21	-	-	-	-	2.40	-	-	1.40	.67	2.11
JUN	53.2	1.21	1.69	2.86	.39	.17	-	-	-	-	.80	-	-	1.40	.85	2.74
JUL	83.6	.33	.48	.78	.79	.10	-	-	-	-	1.20	-	-	1.10	.38	1.44
AUG	49.4	.71	2.07	1.32	.79	.11	-	-	-	-	1.60	-	-	1.70	.60	2.24
SEP	152.7	.54	.74	.72	1.02	.12	-	-	-	-	1.70	-	-	1.30	.51	1.43
OCT	89.0	.70	.74	.88	1.37	.21	-	-	-	-	2.50	-	-	2.30	1.21	2.93
NOV	54.1	.46	.85	.85	.69	.09	-	-	-	-	1.20	-	-	3.00	.47	1.11
DEC	42.7	.90	1.21	1.82	.53	.22	-	-	-	-	2.40	-	-	3.50	.72	1.40
YEAR	826.5	.71	1.16	1.22	1.65	.22	-	-	-	-	2.93	-	-	2.37	.84	2.02

Country : SWEDEN  
 Station : RORVIK  
 Year : 1990

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	100.4	.56	.42	.37	11.36	.94	-	-	-	-	13.90	-	-	2.90	.42	.80
FEB	77.1	.81	.58	.79	8.59	1.03	-	-	-	-	15.80	-	-	3.70	.76	1.09
MAR	23.4	.81	.89	1.01	17.08	1.84	-	-	-	-	25.90	-	-	1.90	1.07	1.44
APR	50.2	.96	1.25	1.33	2.50	.33	-	-	-	-	6.40	-	-	1.50	.86	1.89
MAY	75.0	.58	.68	1.63	.46	.06	-	-	-	-	.80	-	-	1.50	.62	1.05
JUN	91.6	.69	.92	1.51	.44	.07	-	-	-	-	1.00	-	-	1.00	.57	.98
JUL	61.9	.48	.48	1.11	1.04	.15	-	-	-	-	1.90	-	-	1.20	.29	.73
AUG	70.2	.71	1.27	1.16	1.19	.18	-	-	-	-	2.50	-	-	1.40	.53	1.28
SEP	106.3	.41	.26	.41	1.17	.15	-	-	-	-	2.40	-	-	1.20	.18	.51
OCT	74.0	.51	.36	.68	2.68	.33	-	-	-	-	4.90	-	-	2.20	.75	1.50
NOV	43.4	.53	.28	.63	.88	.10	-	-	-	-	1.80	-	-	4.20	.39	.85
DEC	79.5	.79	.66	.93	4.27	.50	-	-	-	-	7.60	-	-	3.50	.38	.74
YEAR	853.0	.63	.64	.93	3.81	.41	-	-	-	-	6.20	-	-	2.18	.57	1.07

Country : SWEDEN  
 Station : HOBURG  
 Year : 1990

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	55.0	.88	.46	1.59	3.13	.41	-	-	-	-	18.80	-	-	-	2.40	-
FEB	34.7	1.26	.64	1.15	6.12	.84	-	-	-	-	10.60	-	-	-	2.60	-
MAR	16.8	1.14	.75	.89	10.55	1.11	-	-	-	-	16.00	-	-	-	1.30	-
APR	29.9	.98	2.24	1.99	2.02	.54	-	-	-	-	4.00	-	-	-	1.10	-
MAY	25.1	.52	3.04	2.08	.92	.27	-	-	-	-	1.50	-	-	-	.70	-
JUN	16.5	.42	15.29	3.31	1.53	.65	-	-	-	-	2.90	-	-	-	.80	-
JUL	50.7	.47	3.11	1.05	.86	.18	-	-	-	-	1.50	-	-	-	.60	-
AUG	30.6															

Country : USSR  
 Station : RUTSAVA  
 Year : 1990

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N*
JAN	65.3	1.40	.70	.95	1.80	-	-	-	-	-	-	-	-	5.80	.30	.90
FEB	60.4	1.20	.80	1.02	2.10	-	-	-	-	-	-	-	-	3.70	.60	1.40
MAR	42.1	.90	.40	1.28	5.00	-	-	-	-	-	-	-	-	2.70	.20	.30
APR	8.0	1.60	1.10	3.77	1.50	-	-	-	-	-	-	-	-	3.70	.20	.90
MAY	45.7	.20	.10	.97	.30	-	-	-	-	-	-	-	-	3.40	.10	.60
JUN	60.5	.30	.20	.47	.40	-	-	-	-	-	-	-	-	4.50	.10	.60
JUL	90.0	.10	.10	.24	.70	-	-	-	-	-	-	-	-	4.30	.10	.30
AUG	60.8	.40	.70	.98	.20	-	-	-	-	-	-	-	-	4.70	.10	.30
SEP	146.7	.60	.20	.84	.70	-	-	-	-	-	-	-	-	4.40	.20	.50
OCT	124.3	.40	.20	.72	1.00	-	-	-	-	-	-	-	-	4.60	.40	.70
NOV	163.2	.60	.40	.85	.60	-	-	-	-	-	-	-	-	4.70	.20	1.00
DEC	56.5	.90	.60	1.72	2.10	-	-	-	-	-	-	-	-	4.00	.30	1.30
YEAR	923.5	.61	.37	.88	1.11	-	-	-	-	-	-	-	-	4.21	.23	.73

\*) Reporting NH4+

Country : USSR  
 Station : LAHEMAA  
 Year : 1990

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N*
JAN	58.5	.20	.10	.50	1.20	.10	-	-	-	-	1.40	-	-	10.70	.10	.30
FEB	79.6	.40	.20	.57	.40	.10	-	-	-	-	1.30	-	-	3.50	.20	.60
MAR	44.4	.40	.30	.45	.60	-	-	-	-	-	.90	-	-	1.70	.10	.30
APR	13.3	.60	1.00	1.57	.40	.10	-	-	-	-	.20	-	-	-	-	-
MAY	37.2	.40	.40	.98	.20	.10	-	-	-	-	.40	-	-	-	-	-
JUN	35.5	.20	.10	.97	.30	.10	-	-	-	-	.20	-	-	-	-	-
JUL	24.7	.30	.50	1.17	.40	.10	-	-	-	-	.70	-	-	2.10	.10	.50
AUG	41.1	.10	-	.78	.20	-	-	-	-	-	.30	-	-	1.60	.10	.30
SEP	17.1	.30	.10	1.38	.20	.10	-	-	-	-	1.70	-	-	1.60	.10	.20
OCT	48.4	.20	-	.75	.60	-	-	-	-	-	.70	-	-	1.70	-	.60
NOV	50.2	.20	-	.47	.30	-	-	-	-	-	.50	-	-	3.20	.10	.40
DEC	17.5	.70	.20	1.08	.20	-	-	-	-	-	.90	-	-	4.40	.20	.60
YEAR	467.5	.30	.26	.75	.47	.10	-	-	-	-	.82	-	-	3.39	.12	.42

\*) Reporting NH4+

Country : POLAND  
 Station : LEBA  
 Year : 1990

Sampler type : BULK  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	34.1	.47	.53	1.02	1.30	.22	9.00	3.21	-	29.00	2.78	-	-	-	-	-
FEB	47.3	.52	.62	1.31	3.86	.52	4.90	5.12	-	26.00	6.55	-	-	-	-	-
MAR	29.8	.48	.97	1.16	2.48	.36	8.80	3.79	-	48.00	4.97	-	-	-	-	-
APR	28.2	.50	1.58	3.15	2.13	.34	11.50	6.03	-	18.00	4.20	-	-	-	-	-
MAY	52.5	.43	.63	1.76	.67	.11	5.70	4.65	-	21.00	1.69	-	-	-	-	-
JUN	16.4	.89	2.38	2.76	.31	.19	8.70	9.89	-	22.00	1.22	-	-	-	-	-
JUL	71.6	.66	.83	1.25	.61	.07	11.00	10.11	-	18.00	.61	-	-	-	-	-
AUG	64.7	.42	.57	.90	.36	.06	-	-	-	-	.36	-	-	-	-	-
SEP	197.6	.33	.37	.57	.75	.11	6.20	3.02	-	53.00	1.39	-	-	-	-	-
OCT	41.6	.85	.68	1.52	.82	.09	5.50	9.06	-	42.00	1.40	-	-	-	-	-
NOV	109.0	.35	.19	.78	.77	.08	6.20	4.16	-	25.00	1.35	-	-	-	-	-
DEC	40.5	.59	.44	1.19	1.87	.21	7.70	9.00	-	37.00	3.65	-	-	-	-	-
YEAR	733.3	.47	.59	1.11	1.10	.15	7.17	5.32	-	34.93	2.01	-	-	-	-	-

mm NO3N NH4N SO4S-C Na Mg Pb Cd Cu Zn C1 SO2S A-SO4S NO2N T-NO3N T-NH4N

Country : DDR  
 Station : KAP ARKONA  
 Year : 1990

Sampler type : WET ONLY  
 Sampling period : WEEKLY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	C1	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	30.5	.62	.51	1.32	1.31	.24	-	-	-	-	2.43	4.00	-	-	-	-
FEB	24.3	.73	.73	2.06	4.86	.73	-	-	-	-	10.04	3.60	-	-	-	-
MAR	33.6	.57	1.27	1.61	6.13	.83	-	-	-	-	12.13	-	-	-	-	-
APR	22.9	1.33	2.05	2.45	1.23	.26	-	-	-	-	2.20	-	-	-	-	-
MAY	20.8	.98	.95	1.19	1.09	.22	-	-	-	-	2.45	1.20	-	-	-	-
JUN	45.0	.96	1.76	3.33	.44	.16	-	-	-	-	1.08	.90	-	-	-	-
JUL	35.5	.38	.58	1.32	.7											

Country : DENMARK  
 Station : KELDSNOR  
 Year : 1990

Sampler type : WET ONLY  
 Sampling period : DAILY

	mm	NO3N	NH4N	SO4S-C	Na	Mg	Pb	Cd	Cu	Zn	Cl	SO2S	A-SO4S	NO2N	T-NO3N	T-NH4N
JAN	28.4	1.60	1.02	2.12	28.90	3.56	-	-	-	47.63	-	-	-	-	-	-
FEB	32.7	.48	.86	1.08	19.54	2.51	-	-	-	35.08	-	-	-	-	-	-
MAR	24.8	.74	1.01	1.37	19.46	2.58	-	-	-	38.22	-	-	-	-	-	-
APR	20.2	.84	.87	1.40	3.87	.48	-	-	-	5.67	-	-	-	-	-	-
MAY	18.2	.76	1.06	1.58	1.24	.20	-	-	-	2.56	-	-	-	-	-	-
JUN	84.8	.55	.85	1.09	.31	.05	-	-	-	.66	-	-	-	-	-	-
JUL	39.4	.49	2.44	1.13	2.68	.30	-	-	-	5.44	-	-	-	-	-	-
AUG	52.3	.41	1.97	.84	2.08	.28	-	-	-	4.06	-	-	-	-	-	-
SEP	78.4	.53	1.19	.99	4.64	.53	-	-	-	8.32	-	-	-	-	-	-
OCT	24.5	.84	1.46	1.97	8.92	1.60	-	-	-	22.09	-	-	-	-	-	-
NOV	75.3	.43	.45	.71	3.11	.40	-	-	-	5.86	-	-	-	-	-	-
DEC	39.4	.85	1.43	1.06	12.29	1.75	-	-	-	21.54	-	-	-	-	-	-
YEAR	518.4	.63	1.18	1.14	6.91	.91	-	-	-	12.68	-	-	-	-	-	-

## BALTIC SEA ENVIRONMENT PROCEEDINGS

- No. 1 JOINT ACTIVITIES OF THE BALTIC SEA STATES WITHIN THE FRAMEWORK OF THE CONVENTION ON THE PROTECTION OF THE MARINE ENVIRONMENT OF THE BALTIC SEA AREA 1974-1978  
(1979)\*
- No. 2 REPORT OF THE INTERIM COMMISSION (IC) TO THE BALTIC MARINE ENVIRONMENT PROTECTION COMMISSION  
(1981)
- No. 3 ACTIVITIES OF THE COMMISSION 1980
  - Report on the activities of the Baltic Marine Environment Protection Commission during 1980
  - HELCOM Recommendations passed during 1980
 (1981)
- No. 4 BALTIC MARINE ENVIRONMENT BIBLIOGRAPHY 1970-1979  
(1981)
- No. 5A ASSESSMENT OF THE EFFECTS OF POLLUTION ON THE NATURAL RESOURCES OF THE BALTIC SEA, 1980
  - PART A-1: OVERALL CONCLUSIONS
 (1981)\*
- No. 5B ASSESSMENT OF THE EFFECTS OF POLLUTION ON THE NATURAL RESOURCES OF THE BALTIC SEA, 1980
  - PART A-1: OVERALL CONCLUSIONS
  - PART A-2: SUMMARY OF RESULTS
  - PART B: SCIENTIFIC MATERIAL
 (1981)
- No. 6 WORKSHOP ON THE ANALYSIS OF HYDROCARBONS IN SEAWATER  
Institut für Meereskunde an der Universität Kiel, Department of Marine Chemistry, March 23 - April 3, 1981  
(1982)
- No. 7 ACTIVITIES OF THE COMMISSION 1981
  - Report of the activities of the Baltic Marine Environment Protection Commission during 1981 including the Third Meeting of the Commission held in Helsinki 16-19 February 1982
  - HELCOM Recommendations passed during 1981 and 1982
 (1982)
- No. 8 ACTIVITIES OF THE COMMISSION 1982
  - Report of the activities of the Baltic Marine Environment Protection Commission during 1982 including the Fourth Meeting of the Commission held in Helsinki 1-3 February 1983
  - HELCOM Recommendations passed during 1982 and 1983
 (1983)
- No. 9 SECOND BIOLOGICAL INTERCALIBRATION WORKSHOP  
Marine Pollution Laboratory and Marine Division of the National Agency of Environmental Protection, Denmark, August 17-20, 1982, Rønne, Denmark  
(1983)

\* out of print

- No. 10 TEN YEARS AFTER THE SIGNING OF THE HELSINKI CONVENTION  
National Statements by the Contracting Parties on the Achievements in Implementing the Goals of the Convention on the Protection of the Marine Environment of the Baltic Sea Area  
(1984)
- No. 11 STUDIES ON SHIP CASUALTIES IN THE BALTIC SEA 1979-1981  
Helsinki University of Technology, Ship Hydrodynamics Laboratory, Otaniemi, Finland  
P. Tuovinen, V. Kostilainen and A. Hämäläinen  
(1984)
- No. 12 GUIDELINES FOR THE BALTIC MONITORING PROGRAMME FOR THE SECOND STAGE  
(1984)
- No. 13 ACTIVITIES OF THE COMMISSION 1983  
- Report of the activities of the Baltic Marine Environment Protection Commission during 1983 including the Fifth Meeting of the Commission held in Helsinki 13-16 March 1984  
- HELCOM Recommendations passed during 1983 and 1984  
(1984)
- No. 14 SEMINAR ON REVIEW OF PROGRESS MADE IN WATER PROTECTION MEASURES  
17-21 October 1983, Espoo, Finland  
(1985)
- No. 15 ACTIVITIES OF THE COMMISSION 1984  
- Report of the activities of the Baltic Marine Environment Protection Commission during 1984 including the Sixth Meeting of the Commission held in Helsinki 12-15 March 1985  
- HELCOM Recommendations passed during 1984 and 1985  
(1985)
- No. 16 WATER BALANCE OF THE BALTIC SEA  
A Regional Cooperation Project of the Baltic Sea States;  
International Summary Report  
(1986)
- No. 17A FIRST PERIODIC ASSESSMENT OF THE STATE OF THE MARINE ENVIRONMENT OF THE BALTIC SEA AREA, 1980-1985; GENERAL CONCLUSIONS  
(1986)
- No. 17B FIRST PERIODIC ASSESSMENT OF THE STATE OF THE MARINE ENVIRONMENT OF THE BALTIC SEA AREA, 1980-1985; BACKGROUND DOCUMENT  
(1987)
- No. 18 ACTIVITIES OF THE COMMISSION 1985  
- Report of the activities of the Baltic Marine Environment Protection Commission during 1985 including the Seventh Meeting of the Commission held in Helsinki 11-14 February 1986  
- HELCOM Recommendations passed during 1986  
(1986)\*
- No. 19 BALTIC SEA MONITORING SYMPOSIUM  
Tallinn, USSR, 10-15 March 1986  
(1986)
- No. 20 FIRST BALTIC SEA POLLUTION LOAD COMPILATION  
(1987)

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- No. 21 SEMINAR ON REGULATIONS CONTAINED IN ANNEX II OF MARPOL 73/78 AND REGULATION 5 OF ANNEX IV OF THE HELSINKI CONVENTION  
National Swedish Administration of Shipping and Navigation;  
17-18 November 1986, Norrköping, Sweden  
(1987)
- No. 22 SEMINAR ON OIL POLLUTION QUESTIONS  
19-20 November 1986, Norrköping, Sweden  
(1987)
- No. 23 ACTIVITIES OF THE COMMISSION 1986  
- Report on the activities of the Baltic Marine Environment Protection Commission during 1986 including the Eighth Meeting of the Commission held in Helsinki 24-27 February 1987  
- HELCOM Recommendations passed during 1987  
(1987)\*
- No. 24 PROGRESS REPORTS ON CADMIUM, MERCURY, COPPER AND ZINC  
(1987)
- No. 25 SEMINAR ON WASTEWATER TREATMENT IN URBAN AREAS  
7-9 September 1986, Visby, Sweden  
(1987)
- No. 26 ACTIVITIES OF THE COMMISSION 1987  
- Report on the activities of the Baltic Marine Environment Protection Commission during 1987 including the Ninth Meeting of the Commission held in Helsinki 15-19 February 1988  
- HELCOM Recommendations passed during 1988  
(1988)
- No. 27A GUIDELINES FOR THE BALTIC MONITORING PROGRAMME FOR THE THIRD STAGE;  
PART A. INTRODUCTORY CHAPTERS  
(1988)
- No. 27B GUIDELINES FOR THE BALTIC MONITORING PROGRAMME FOR THE THIRD STAGE;  
PART B. PHYSICAL AND CHEMICAL DETERMINANDS IN SEA WATER  
(1988)
- No. 27C GUIDELINES FOR THE BALTIC MONITORING PROGRAMME FOR THE THIRD STAGE;  
PART C. HARMFUL SUBSTANCES IN BIOTA AND SEDIMENTS  
(1988)
- No. 27D GUIDELINES FOR THE BALTIC MONITORING PROGRAMME FOR THE THIRD STAGE;  
PART D. BIOLOGICAL DETERMINANDS  
(1988)
- No. 28 RECEPTION OF WASTES FROM SHIPS IN THE BALTIC SEA AREA  
- A MARPOL 73/78 SPECIAL AREA  
(1989)
- No. 29 ACTIVITIES OF THE COMMISSION 1988  
- Report on the activities of the Baltic Marine Environment Protection Commission during 1988 including the Tenth Meeting of the Commission held in Helsinki 14-17 February 1989  
- HELCOM Recommendations passed during 1989  
(1989)

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- No. 30 SECOND SEMINAR ON WASTEWATER TREATMENT IN URBAN AREAS  
6-8 September 1987, Visby, Sweden  
(1989)
- No. 31 THREE YEARS OBSERVATIONS OF THE LEVELS OF SOME RADIONUCLIDES IN THE  
BALTIC SEA AFTER THE CHERNOBYL ACCIDENT  
Seminar on Radionuclides in the Baltic Sea  
29 May 1989, Rostock-Warnemünde, German Democratic Republic  
(1989)
- No. 32 DEPOSITION OF AIRBORNE POLLUTANTS TO THE BALTIC SEA AREA 1983-1985 AND  
1986  
(1989)
- No. 33 ACTIVITIES OF THE COMMISSION 1989  
- Report on the activities of the Baltic Marine Environment Protection Commission during 1989  
including the Eleventh Meeting of the Commission held in Helsinki 13-16 February 1990  
- HELCOM Recommendations passed during 1990  
(1990)\*
- No. 34 STUDY OF THE RISK FOR ACCIDENTS AND THE RELATED ENVIRONMENTAL  
HAZARDS FROM THE TRANSPORTATION OF CHEMICALS BY TANKERS IN THE  
BALTIC SEA AREA  
(1990)
- No. 35A SECOND PERIODIC ASSESSMENT OF THE STATE OF THE MARINE ENVIRONMENT  
OF THE BALTIC SEA, 1984-1988; GENERAL CONCLUSIONS  
(1990)
- No. 35B SECOND PERIODIC ASSESSMENT OF THE STATE OF THE MARINE ENVIRONMENT  
OF THE BALTIC SEA, 1984-1988; BACKGROUND DOCUMENT  
(1990)
- No. 36 SEMINAR ON NUTRIENTS REMOVAL FROM MUNICIPAL WASTE WATER  
4-6 September 1989, Tampere, Finland  
(1990)
- No. 37 ACTIVITIES OF THE COMMISSION 1990  
- Report on the activities of the Baltic Marine Environment Protection Commission during 1990  
including the Twelfth Meeting of the Commission held in Helsinki 19-22 February 1991  
- HELCOM Recommendations passed during 1991  
(1991)
- No. 38 THIRD BIOLOGICAL INTERCALIBRATION WORKSHOP  
27-31 August 1990, Visby, Sweden  
(1991)

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