EMEP Assessment Report

Contribution form Germany

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1. National Emissions

The emissions of major air pollutants have decreased substantially in Germany during the last two decades (see fig.1):

SO_2: Reduction by more than 90%

NO_2: Reduction by about 40%

Particles: Reduction by more than 90%

VOCs: Reduction by about 50%

This is the result of a bunch of emission reductions measures put into force around 1987 and the almost complete shut down of rotten industrial installations in the eastern part of Germany in the years after the reunion in 1989.

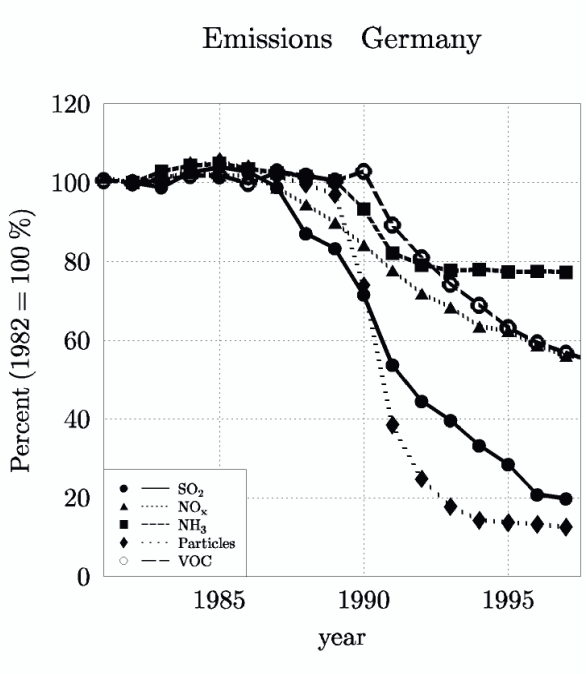


Fig. 1. Emissions in Germany relative to the values of the year 1982.

Most of the reductions occurred between 1990 and 1995. Since then, there is some slow down, but emissions are still decreasing

2. SO_2 and NO_2

The concentrations of SO_2 and NO_2 have changed accordingly to the emissions. As can be seen from fig 2. and 3., they are dominated by downward trends:

SO_2: approximately a factor of 10 since 1980,
NO_2: approximately a factor of 2 since 1980.

Additionally, events of very high concentrations of SO_2, which have been observed frequently in the 80's during certain meteorological conditions, have almost vanished. The trends are site dependent: Lowland sites show more pronounced trends than mountain sites. As the mountain sites have much lower concentrations over the whole period than lowland sites, this means, that the spread between different sites/areas is much smaller now than it has been in the mid 80's, i.e. the concentration fields are spatially more homogenous now.

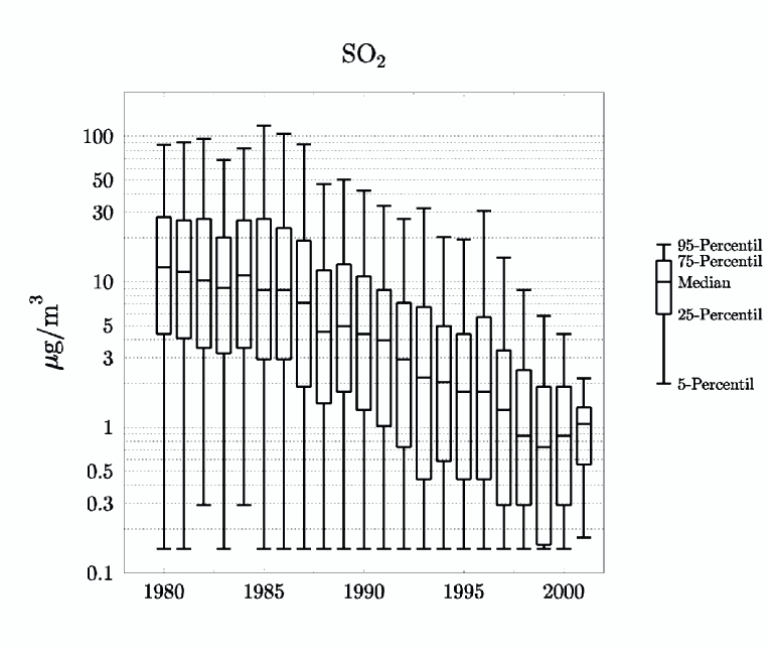


Fig 2. Sulphur dioxide concentration in Germany. Combined results from 8 sites.

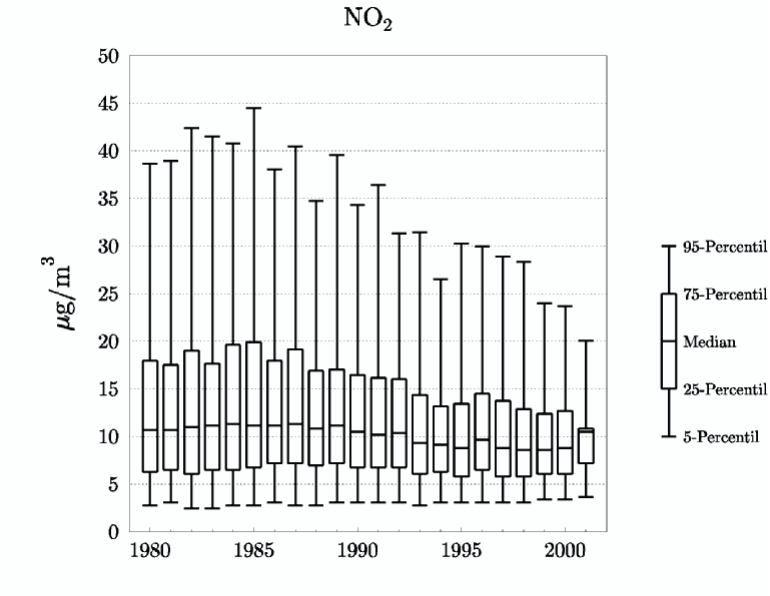
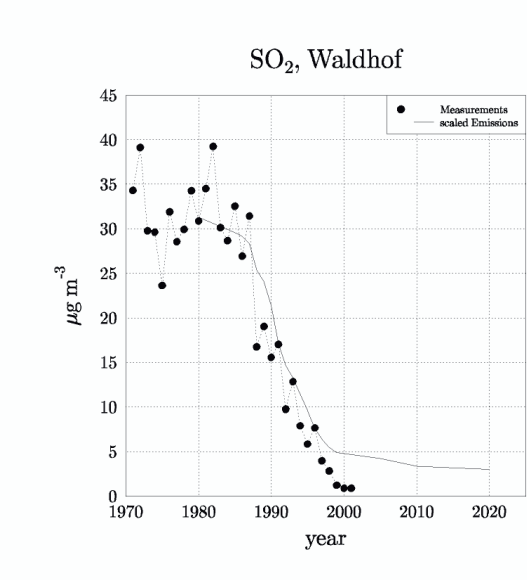
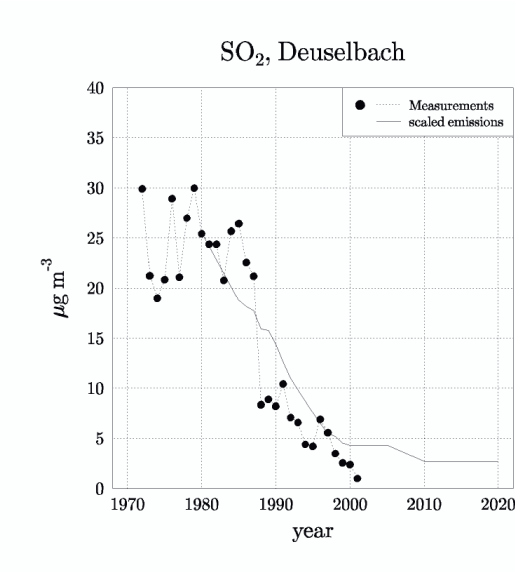


Fig 3. Nitrogen dioxide concentration in Germany. Combined results from 8 sites.

The timing and amount of the trends for SO_2 and NO_2 can be explained reasonably well for individual sites by the EMEP gridded emissions and the trajectory climatology for the sites (Fig 4. a-d, for technical details see appendix). For SO_2 the relative change in concentration seems to be larger than the relative change of the emissions, which may be an indication of non-linearity in the degrading process.


SO2, Waldhof
Measurements
scaled Emissions
μg m-3
year


SO2, Deuselbach
Measurements
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μg m-3
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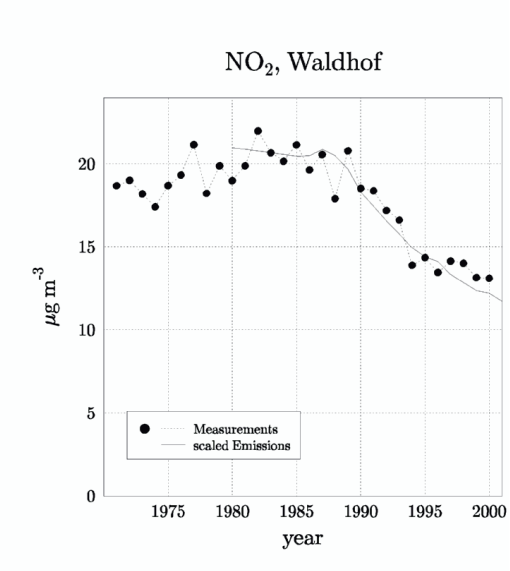
NO2, Waldhof
Measurements
scaled Emissions
μg m-3
year

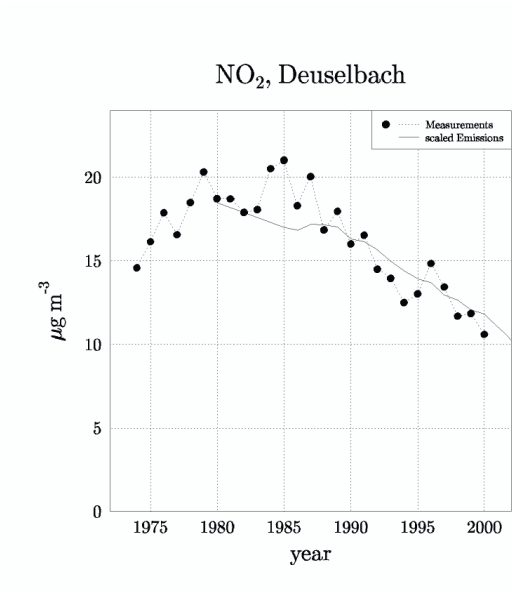

Fig. 4 a-d. Trends for SO_2 and $NO_{2\ for}$ two German EMEP sites compared to trajectory weighted emissions (see text for details)

3. Ions in Precipitation

The development of the concentrations in precipitation between 1985 and 2000 is compound dependent (Fig. 5. to 8.):

Sulphate:	Downward trend, about a factor of 2
H^+:	Downward trend, about a factor of 2
Nitrate:	Very weak downward trend
Ammonium:	Very weak downward trend

The trends for sulphate and acidity (expressed as H^+-concentration) are substantial but for the nitrogen compounds they are less obvious. The trend for sulphate is much smaller than expected from the SO_2- emissions if one assumes a linear relation between emissions and sulphate concentration in precipitation. In general for all ions, the trends are more pronounced for the peak values than for the averages.

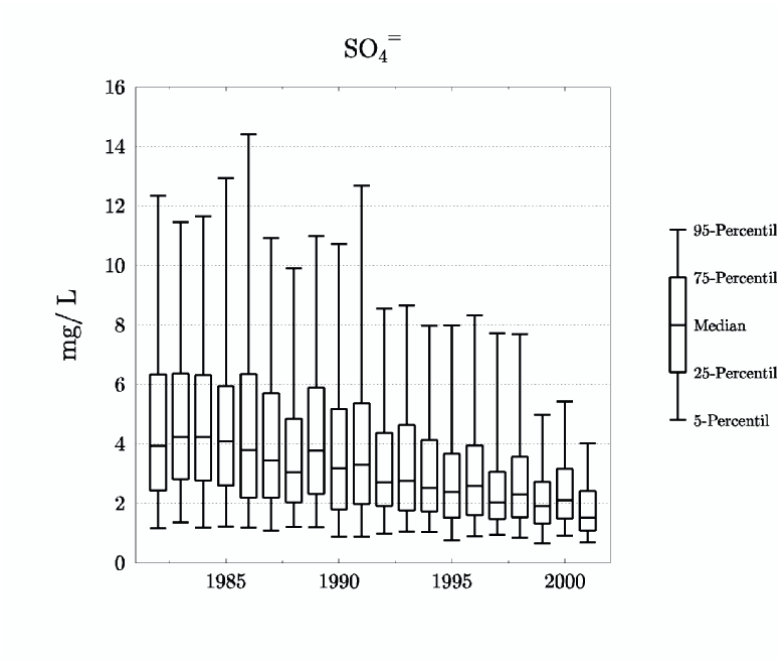

Fig 5. Sulfate in precipitation. Combined results from 8 sites.

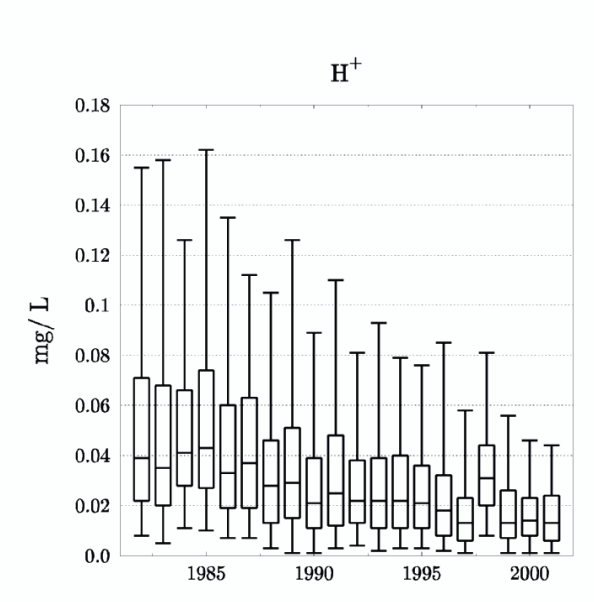

Fig 6. Hydrogen-ion concentration in precipitation. Combined results from 8 sites.

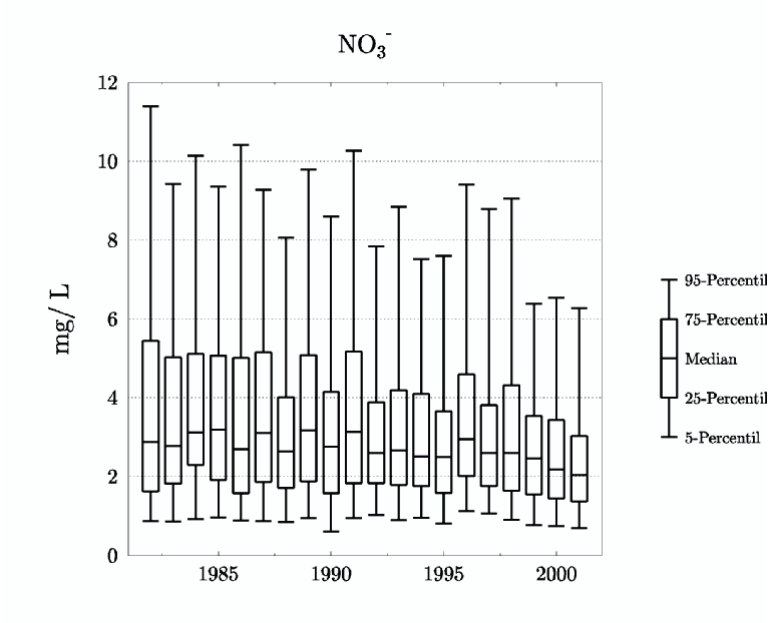

Fig. 7. Nitrate in precipitation in Germany. Combined results from 8 sites.

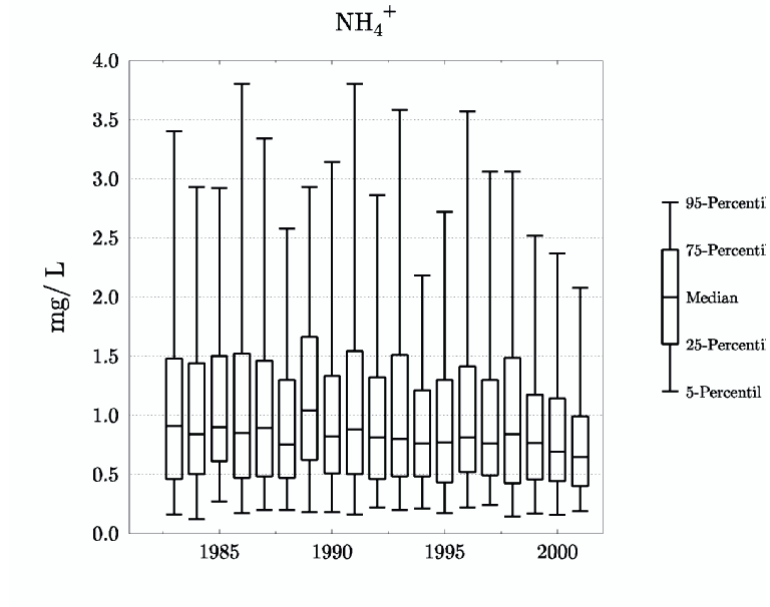

Fig. 9 Ammonium in precipitation in Germany. Combined results from 8 sites.

4. Ozone

Ozone as an air pollutant is characterized by episodic events of high concentrations occurring regionally under certain meteorological conditions. The comparatively coarse network of EMEP-sites thus may not be able to cover important features of the ozone concentration field.

For that reason, the assessment of ozone is augmented by data from a far larger network of sites. For the German EMEP sites there is no obvious trend in ozone, at most there may be some indication of a weak upward trend for medium concentrations (Fig. 9.).
The combined results from about 300 (number varies from year to year) ozone sites in Germany between 1990 and 1997 reveal a much clearer picture (Fig. 10.):
Pronounced downward trends for the high and very high percentiles of the frequency distribution of daily ozone maxima together with an obvious upward trend for low and medium percentiles. The downward trends of the high percentiles can be explained by the decreasing concentrations of the precursors (NO_x and VOCs), which does result in less efficient photochemical ozone production. The upward trends of the lower percentiles can also be attributed to decreasing NO: The titration of ozone by NO is the dominant impact of NO_x on ozone during meteorological conditions, which are not favourable for photochemical ozone production. Therefore, lower NO means a lower efficiency of titration, which in turn leads to higher ozone concentrations under those conditions. There may also be an underlying upward trend of the hemispheric background ozone.

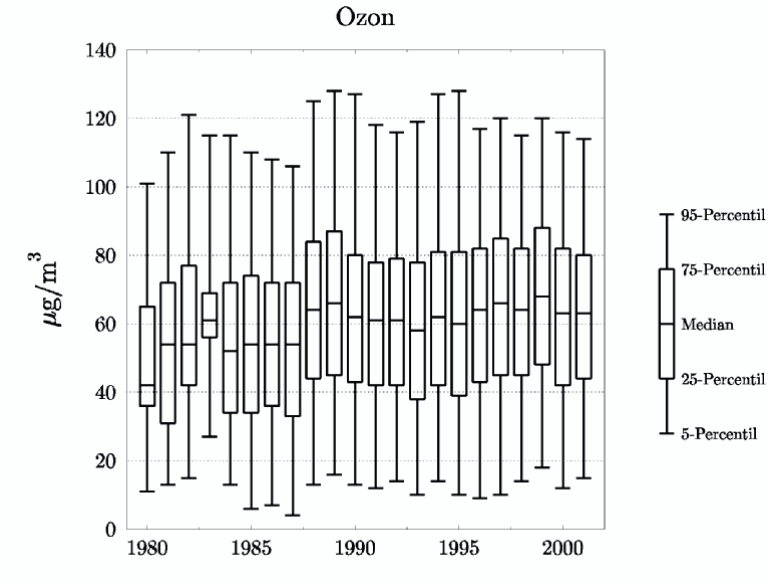

Fig. 9. Ozone concentration in Germany. Combined values from 8 sites.

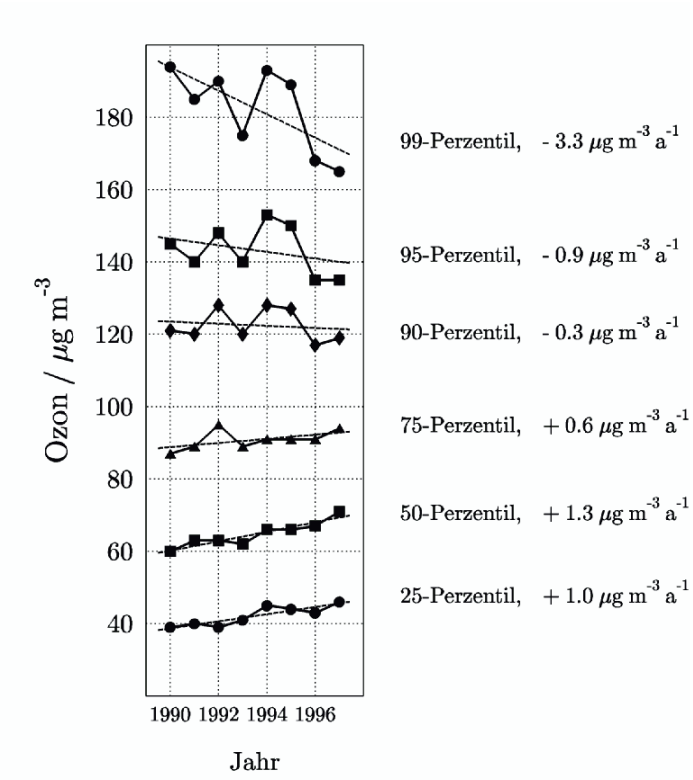

Fig 10. Percentiles of ozone. Combined daily maximum values from about 300 sites in Germany.

5. Particles

Particulate Matter became an issue for EMEP only recently. On the other hand, the determination of the particle mass concentration is integral part of the measurement program at German EMEP sites since more than twenty years now. Like most of the other air pollutants, the PM mass concentration and the concentration of particulate sulphur show significant trends:

Particles Mass: Downward trend, approximately a factor of 2.5 since 1980,

Sulphur in Particles: Downward trend, approximately a factor of 3 since 1980.

Although considerable, these trends are smaller than expected from the respective trends of particle and SO_2 emissions. This may be caused by the non-linearity of secondary particle formation processes and the influence of long-range transport.

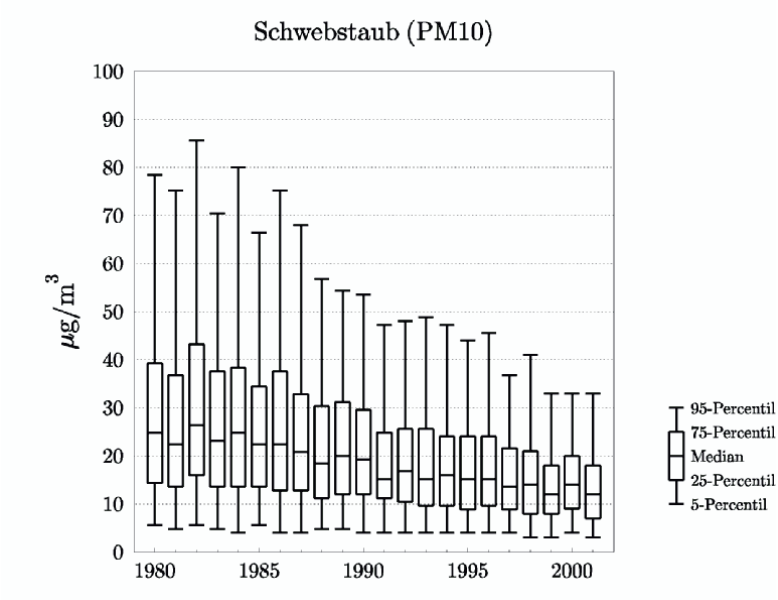

Fig. 11. Particle Concentration in Germany. Combined results from 8 sites.

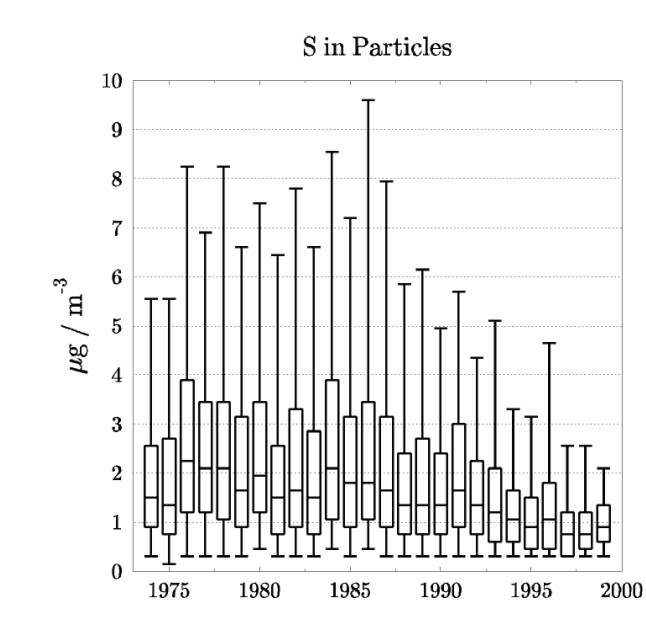

Fig. 12. Sulphur in Particles in Germany. Combined results from 8 sites

7. Overall assessment of the Air Pollution situation in Germany

a) Present state

The air pollution situation in Germany has considerably improved over the last two decades.

The national emissions have effectively been reduced and they are expected to be reduced further where possible and necessary. The concentrations of most air pollutants have decreased considerably. The EU standards for SO_2 and NO_2 are almost nowhere exceeded now. The frequency, intensity and spatial extension of high-ozone episodes are much smaller now than in the early 1990s. The „acid rain"-problem has been solved to a large extend.

b) Further needs

There are still some areas, where critical loads are exceeded substantially. (This is partially caused by long recovery times). The EU-standards for ozone concerning crop protection are exceeded in large areas. The projected more stringent EU-standard for ozone concerning health protection is presently exceeded to some extend. The EU-standards for particles will be difficult to meet in some areas. Common to the last three mentioned problems is, that they are largely influenced by long-range and hemispherical transport and can therefore not be tackled by national means alone.

8. Appendix: Technical details.

a) Box-Whisker-Plots

The box-whisker-plots for sulphur and nitrogen compounds in air and precipitation as those for particles are based on daily means values of the sites Westerland (DE01), Zingst (DE09), Waldhof-Langenbrügge (DE02), Neuglobsow (DE07), Deuselbach (DE04), Schmücke (DE08), Schauinsland (DE03) and Brotjacklriegel (DE05) (Zingst, Neuglobsow and Schmücke only after 1992). All the daily values of the 8 (or 5) sites from a particular year were treated as one ensemble from which the percentiles are determined. These ensembles may
be regarded as representative for what is to be expected in rural areas in Germany. It should be mentioned, that the 5-Percentile is mostly determined by the detection limit of the respective measurement method.

b) Fig 4 a-d.

- for a site under concern, all available trajectories (EMEP webdab) are used to calculate trajectory crossing frequencies for each "emep - grid - cells" (150 km x 150 km). This gives some kind of "trajectory climatology". The trajectory crossing frequencies are then used as weight factors, which where multiplied with the gridded annual emissions to give some kind of "effective emission" for the considered site. These are then scaled to give numerical values

comparable to the observed concentrations. Then, the relative trend of the “effective emissions” and the concentrations can be compared.