National Assessment – Austria

1 Introduction

The national assessment of Austrian EMEP data covers sulphur dioxide, particulate sulphate, NOx, ozone, and S- and N-compounds in the wet deposition. For each pollutant a short description and interpretation of concentration or deposition levels and trends are given. The data from the three Austrian EMEP sites are amended by data from other Austrian background sites to improve the spatial and temporal coverage. The annex comprises an overview about the location of the monitoring sites and the monitoring devices used.

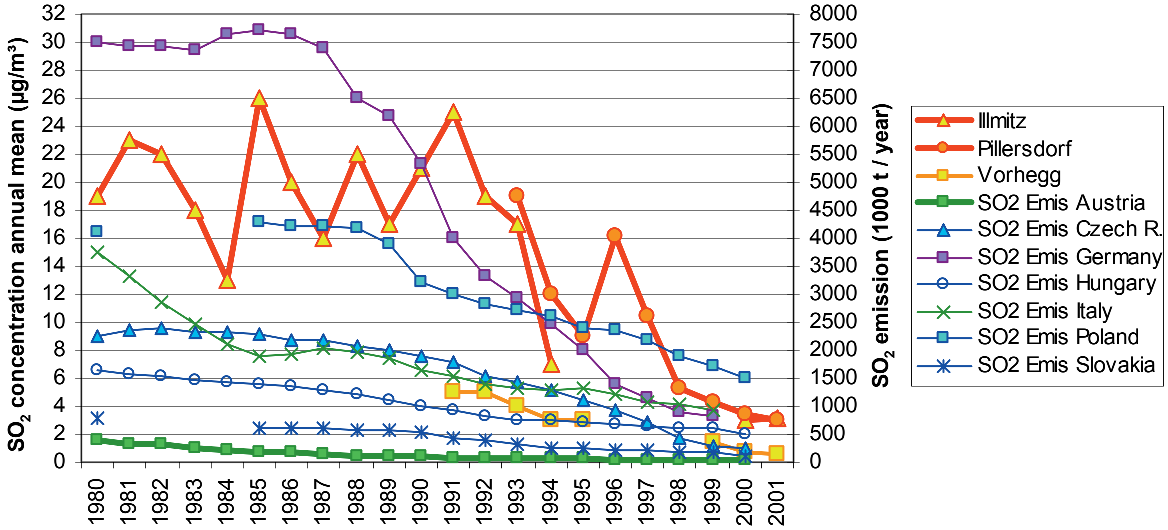
2 Sulphur

2.1 SO_2

SO_2 background concentrations in Austria originated to the major part from emissions outside Austria during the last two decades, since SO_2 emissions in Austria's northern and eastern neighbouring countries by far exceeded the emissions in Austria itself. Especially in the northern and eastern part of Austria until winter 1996/97 transboundary SO_2 transport was responsible for concentrations peaking up to more than 200 µg/m^3 as 1-hour mean. According to present knowledge, large point sources (mainly power plants) were - and still are - the major source of SO_2 background pollution in Austria.

Until 1993 (and including 1996), in the north-eastern part of Austria annual mean values between 15 and 25 µg/m^3 (with quite large inter-annual variations) have been recorded. The decrease of SO_2 emissions that started in the late 1980s did not result in a similar decline of SO_2 levels, which retained the concentration level of the 1980s until 1993. After 1993, a strong decrease of SO_2 concentrations was observed, interrupted by an intermediate increase in 1996. The trend of annual mean values of the SO_2 concentration at Illmitz, Pillersdorf, and Vorhegg for the years 1980 to 2001 and the annual SO_2 emissions in Austria, Germany, Italy, the Czech Republic, Poland, Hungary, Slovakia, and Slovenia are given in Figure 1.

Figure 1: SO_2 annual mean values at Illmitz, Pillersdorf, Stolzalpe and Vorhegg, 1980 - 2000



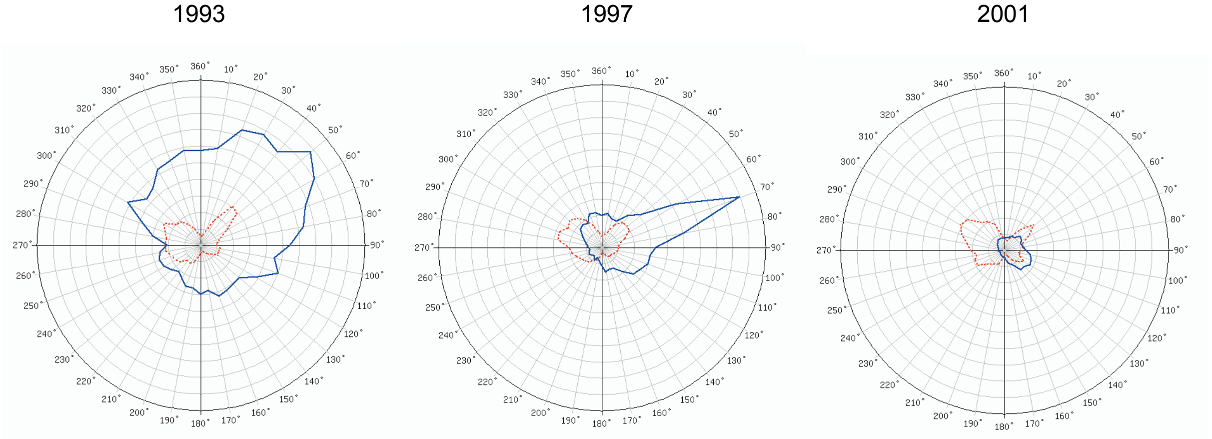
The background sites in north-eastern Austria (Illmitz and Pillersdorf) and stations in the Czech Republic (Kosetice, Svratouch), and Slovakia (Chopok, Stara Lesna, Liesek) - the Czech and Slovakian data were retrieved from the EMEP data base - show a quite similar trend in eastern central Europe[1]. Anyhow, in 1996 Pillersdorf recorded higher SO_2 concentrations than the sites in the Czech and Slovak Republic, whereas the further decline in SO_2 levels was in Austria more pronounced than in the Slovak Republic and Hungary.

Meteorological conditions could be identified as one key factor for high SO_2 levels in north-eastern Austria, beside the development of SO_2 emissions. During the last decade, winter 1992/93, 1993/94, 1995/96 and 1996/97 were affected by long-lasting high pressure regions over eastern Europe with advection of very cold air masses of continental origin with quite unfavourable dispersion conditions. Such conditions in January and December 1996 and January 1997 were responsible for 1-hour mean values above 200 µg/m^3 and monthly mean values above 50 µg/m^3 in Pillersdorf.

The further decrease of SO_2 emissions since 1997 and the absence of long-lasting cold high pressure situations over eastern central Europe, but relatively warm winter seasons caused a strong decline in SO_2 concentrations since then.

During the early 1990s, the amount of SO_2 advection from north-west decreased (see wind roses for SO_2 in Pillersdorf, Figure 2), corresponding to the decrease of emissions in eastern Germany and the Czech Republic. Later SO_2 advection from the east (advection from sources in Slovakia and Hungary) decreased.

Figure 2: Wind roses for SO_2, Trend 1993 – 2001, Pillersdorf. The radius of the wind frequency (··········) represents 20%, the radius of the SO_2 concentration (———) represents 40 µg/m^3.



1993 1997 2001

In the alpine regions of Austria, SO_2 levels were much lower; during the early 1990s, annual mean values between 3 and 5 µg/m^3 have been measured. In the south-eastern part of Austria, SO_2 emissions from the power plant in Šoštanj (Slovenia) resulted in high SO_2 levels not only in Arnfels at the southern border of Austria, but also in Vorhegg. The benefits of the desulphurisation installed in 1995 and 2001 could be clearly recorded in Austria, the annual mean in Arnfels decreased from 21 µg/m^3 in 1993 to 5 µg/m^3 in 2001, in Vorhegg from 5 to 1 µg/m^3.

In the whole northern alpine region of Austria, long range transport from north-east gives the major contribution to SO_2 background levels, which, anyhow, have decreased from 3 µg/m^3 to below 1 µg/m^3 as annual mean between 1992 and 2001 in St. Koloman.

2.2 Particulate Sulphate

The trend of particulate sulphate in Illmitz, in comparison with gaseous SO_2, is given in Figure 3. The amount of the decrease of particulate sulphate levels is by far lower than of SO_2. This difference might be attributed to differences in transport distance; SO_2 mainly originates from point sources up to some 100 km distance from Austria, whereas particulate sulphate might be formed by atmospheric processes in a much larger area. The decrease of

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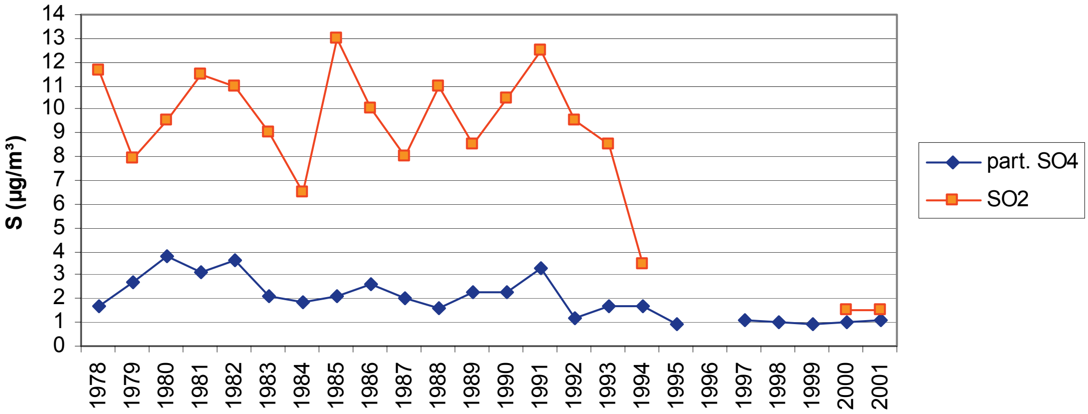
[1] The concentration at the Hungarian site Kapuszta shows from 1987 to 1994 a very low correlation to the data from the above mentioned monitoring sites

sulphate levels was relatively smooth from more than 3 µgS/m^3 in the early 1980s to about 1 µgS/m^3 in recent years.

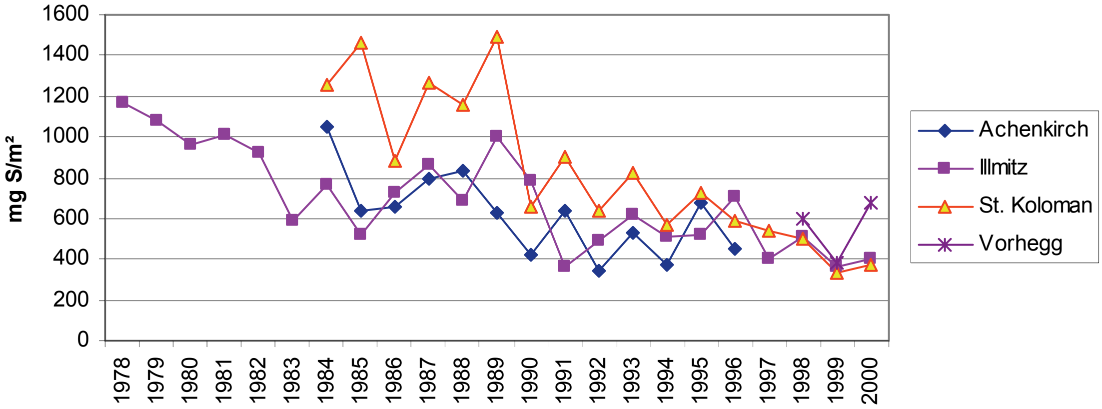
Figure 3: Concentration of SO_2 and particulate Sulphate in Illmitz, annual mean (µgS/m^3)



2.3 Wet deposition of sulphate

The wet deposition of sulphate (Figure 4) shows, different to gaseous SO_2, a distinct decline between 1989 and 1990 (or 1991) both in Illmitz and in St. Koloman. Especially in the northern alpine regions (St. Koloman) with high precipitation and main cloud advection from north to west, a sharp decline was observed after 1989. During the 1990s, a lower decrease with quite large inter-annual variations was observed.

Figure 4: Wet deposition of Sulphate, annual sum (mg S/m^2.year)

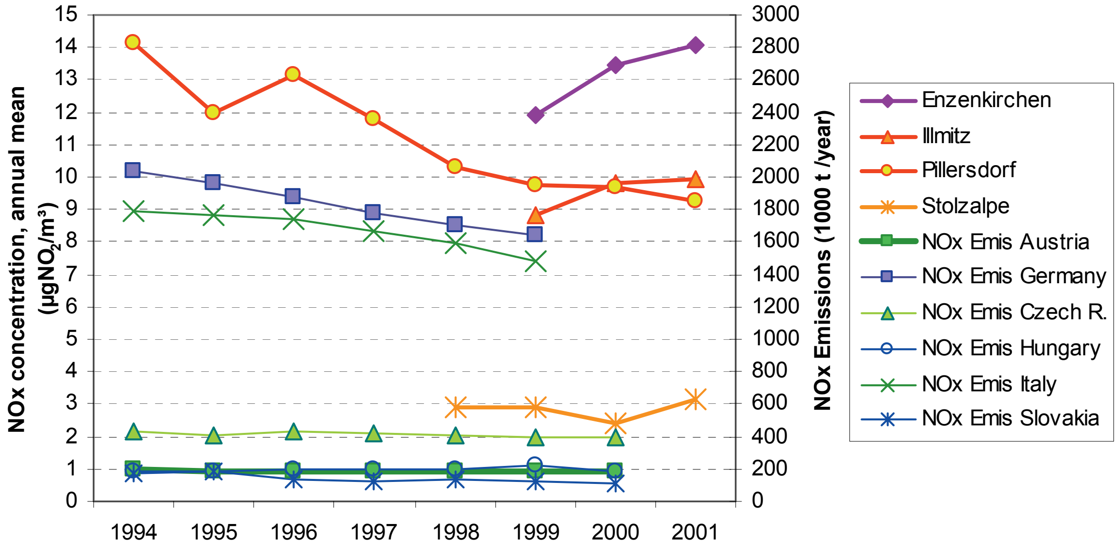


3 Nitrogen

3.1 NO_2

The available time series for NOx concentrations (Figure 5) show a small decline in background concentrations in north-eastern Austria (Pillersdorf) since 1994, which fairly corresponds to the decrease in NOx emissions in Austria's northern neighbouring countries. The unfavourable dispersion conditions in winter 1995/96 and 1996/96 resulted in higher NOx levels in 1996. The increase of mean NOx concentrations during the last two years can not yet – with respect to lacking emission data – be interpreted.

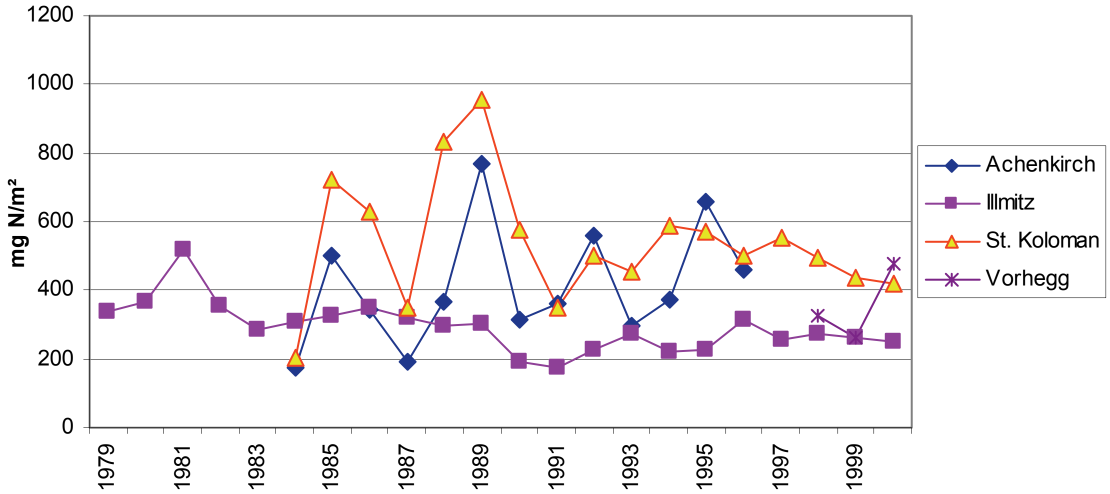
Figure 5: NOx, annual mean concentrations (µgNO$_2$/m³), annual emissions (kt/year)



3.2 Wet deposition of nitrate

The wet deposition of nitrate shows no clear trend at all. At the northern alpine sites St. Koloman and Achenkirch, the highest deposition values of oxidised nitrogen were observed in 1988 and 1989, with very large inter-annual variations in the 1980s. In Illmitz, nitrate deposition in the last years is significantly lower than in the 1980s, but higher than in the early 1990s.

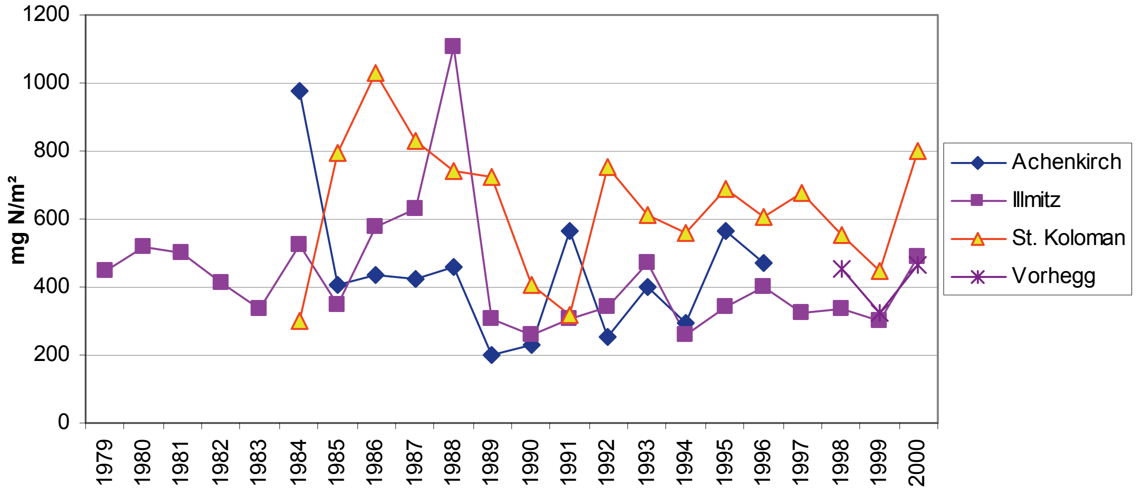
Figure 6: Wet deposition of oxidised nitrogen (mgN/m^2.year)



3.3 Wet deposition of ammonia

Large variations could be observed for the deposition of ammonia, with very high depositions at Illmitz and St. Koloman in the late 1980s. In recent years the deposition of reduced nitrogen in Illmitz is lower than in the early 1980s, whereas much higher ammonia depositions are observed in St. Koloman.

Figure 7: Wet deposition of reduced nitrogen (mgN/m^2.year)



4 Ozone

Background ozone concentrations, both mean and short term peak values, vary largely in Austria due to the topographic situation (from the Pannonian plain to mountains above 3000 m), the influence of agglomeration plumes (mainly Vienna) and transboundary transport of highly polluted air masses (often from Italy and Germany). Figure 8 shows the altitudinal variation of the annual mean values at representative stations: Sonnblick (3106 m), Zillertaler Alpen and Gerlitzen at about 1800 north and south of the central alpine ridge, St. Koloman and Vorhegg at about 1000 m north and south of the central alpine ridge, and Illmitz and Pillersdorf in the extra-alpine lowlands in north-eastern Austria. The lowest mean values are measured at Illmitz (117 m), the highest at Sonnblick (3106 m). Almost all background stations in Austria show a low increasing trend, which is, in most cases, not very significant. From 16 background ozone monitoring stations with time series starting 1992 or earlier, only three in quite different locations (amongst them Sonnblick) have an increasing trend significant at 99% confidence level[2] with an increase up to 0.68 ppb/year, and two at 95% confidence. No clear spatial pattern of these trends can be seen throughout Austria; anyhow, in north-eastern Austria, the region with the largest contribution of regional ozone formation, the sites west of Vienna show a decrease, the sites east of Vienna an increase.

The concept of cumulative ozone concentrations and critical levels, defined as AOT40 values, has been developed within the UN/ECE as a means to assess the harmful effects of ozone to vegetation. AOT40 values are in the present report calculated according to the definitions elaborated at the UN/ECE workshop in Kuopio 1996[3].

As can be seen in Figure 9 and Figure 10, both the critical level for forests, pasture and natural vegetation (10000 ppb.h) and for crops (3000 ppb.h) are exceeded at all background locations in Austria. The highest AOT40 values are observed at high alpine sites, with the maximum ever registered in Austria at Gerlitzen in 1993 both for forest (47.3 ppm.h) and crops (27.8 ppm.h). On general, AOT40 levels increase with altitude. The inter-annual variation is quite large at all sites, with high values at most sites in 1994 and 2000. Most sites show an upward trend of both AOT40 values, but with low statistical significance.

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[2] Mann-Kendall-Test

[3] Workshop on Critical Levels for Ozone in Europe: Testing and Finalising the Concepts. Kuopio, Finland, 15-17 April 1996. UN ECE Convention on Long-range Transboundary Air Pollution.

Figure 8: Ozone, annual mean values (ppb)

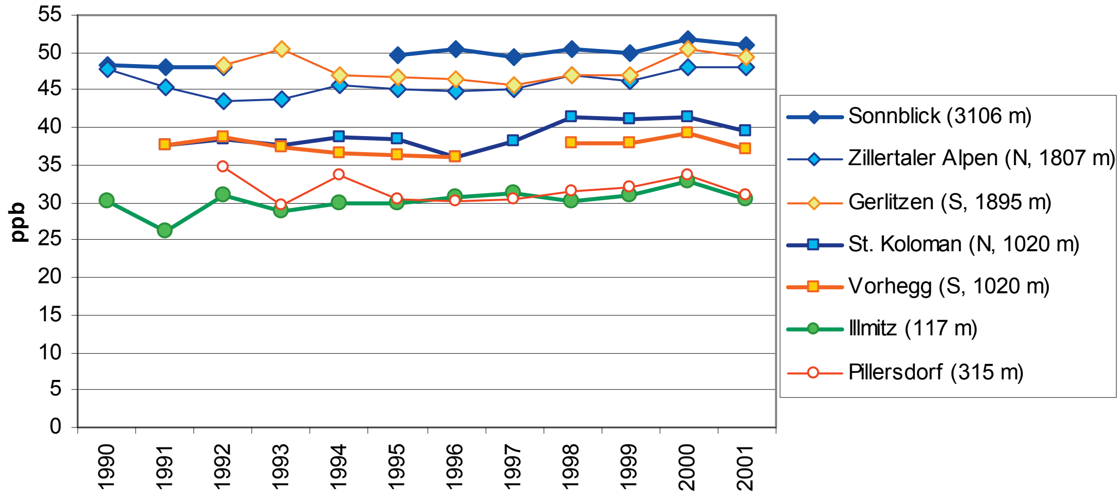


Figure 9: AOT40 values for forests (April – September, daylight hours)

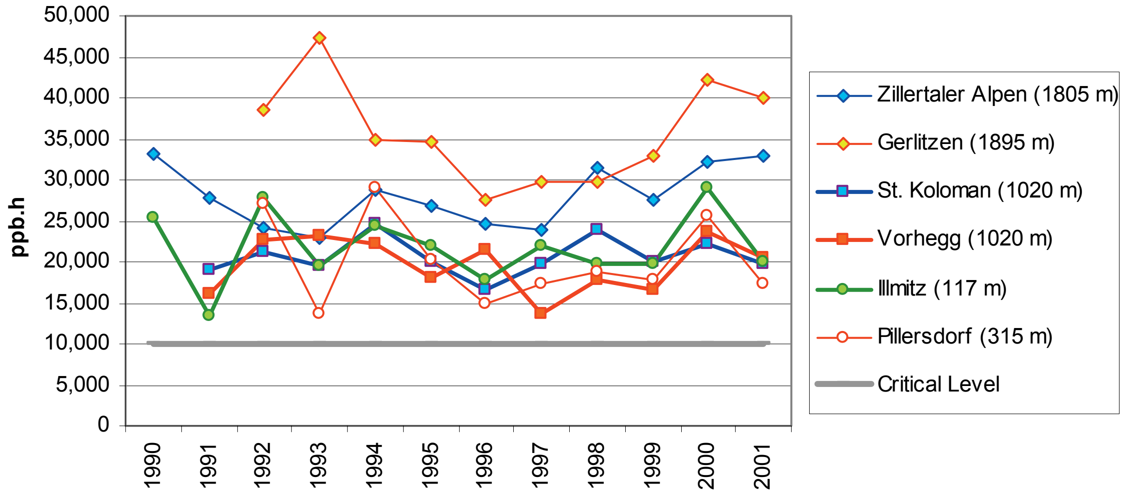
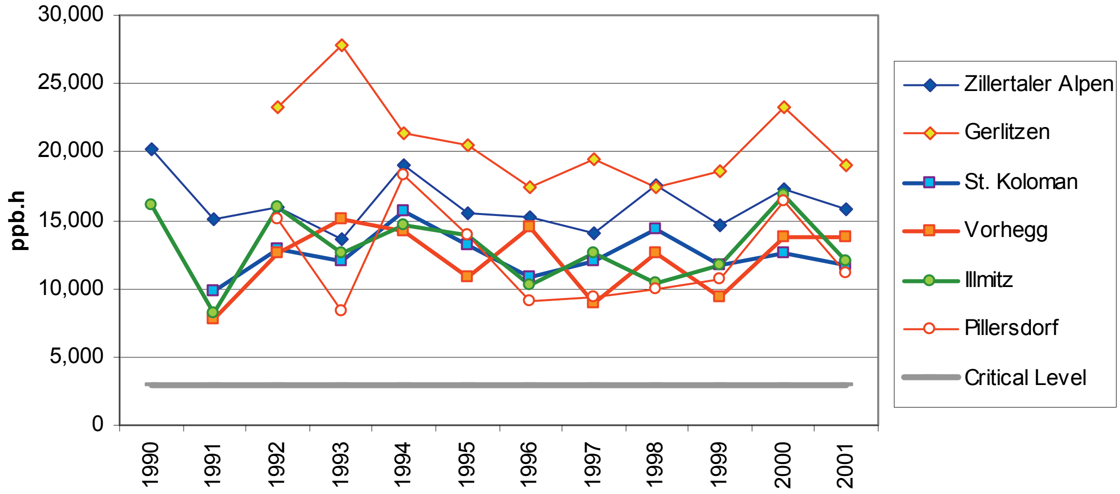


Figure 10: AOT40 values for crops (May – July, daylight hours)



The trend of peak concentrations was calculated using the annual 98-percentiles of the 1-hour mean values. Almost all sites show a slight decreasing trend. Anyhow, from 16 background sites, only one site has a trend significant at 90% confidence level, all other below 90% confidence level.

5 Comparison with model results

This chapter gives some examples of comparisons of measured data with model results available on the EMEP homepage. The comparison comprises (a) gridded model data, with are available for 1999, with measured data at various background sites, and (b) time series for the EMEP sites, for which modelled data are available up to 1996.

5.1 SO_2 and NO_2 background concentrations

The gridded model data (50 km resolution) for SO_2 and NO_2 annual mean concentrations for 1999 were compared with background monitoring sites located in the respective EMEP grid (Table 1). In almost all cases the measured concentration is overestimated by the model. At the alpine sites (those with SO_2 concentrations of 1 µg/m^3), the SO_2 annual mean is overestimated by 100 to 200%, the NO_2 concentration is overestimated by 40 to 130%; the „worst“ cases are St. Koloman and Zöbelboden. The model results fit much better for the extra-alpine sites Enzenkirchen, Illmitz and Pillersdorf. The problems to reproduce measured concentrations in alpine regions by a model with 50 km spatial resolution result from the by far not realistic representation both of topography (transport and dispersion of pollutants) and emissions in the alpine area.

Table 1: Modelled and measured SO_2 and NO_2 annual mean concentrations, 1999, µg/m^3

	SO_2		NO_2	
	Model	Measurement	Model	Measurement
Enzenkirchen	3	2	11	10
Illmitz	6	4	10	8
Pillersdorf	5	4	9	8
St. Koloman	3	1	9	5
Stolzalpe	2	1	4	2
Sulzberg	2	1	7	5
Vorhegg	2	1	5	3
Zöbelboden	3	1	7	3
Klöch	5	3		

5.2 Wet deposition

The precipitation amount in St. Koloman is, for the period 1993 – 1996, largely underestimated; the model gives total precipitations in the range of 800 to 1200 mm/year, compared to measured precipitations between 1500 and 2000 mm. The wet deposition of sulphate in St. Koloman is underestimated by the model, with is mainly due to the inadequate representation of the seasonal variation. The model does not reproduce the high deposition during summer, but, on the other hand, overestimates the sulphate deposition in winter. In Illmitz, much better correspondence can be seen, but the seasonal variation is covered by the model not well enough.

The nitrate deposition and its seasonal cycle are reproduced by the model in St. Koloman quite well, but with overestimations by the model especially during winter. In Illmitz, nitrate deposition is mostly overestimated by the model, especially in winter.

Ammonia deposition shows in St. Koloman a similar behaviour like sulphate, with large underestimations of high observed values during summer by the model, but overestimation of the low winter depositions. In Illmitz, a similar problem, but with lower seasonal amplitude, occurs.

6 Literature

Annual reports about the measurements of the Austrian Federal Environment Agency (including EMEP-data) are available from 1999 onward on the web-page http://www.ubavie.gv.at.

Information about background monitoring in Austria and analyses of the origin of pollutants can be find in:

Spangl W. and J. Schneider (2000). LUFTGÜTEMESSUNGEN UND METEOROLOGISCHE MESSUNGEN DES UMWELTBUNDESAMTES. Umweltbundesamt, Vienna.

Kaiser A., H. Scheifinger, M. Langer (2002): Analyse der Herkunft der gemessenen NO_2-, SO_2- und Ozonkonzentration an der Hintergrundmessstelle Zöbelboden mittels Trajektorienananlyse. Zentralanstalt für Meteorologie und Geodynamik and Umweltbundesamt, Vienna.

Results of this study are published in: Kaiser A., Langer M., Mirtl M., Scheifinger H., Spangl W. (2002): Analysis of Long-range Air Pollutant Transport Using Trajectory Residence Time Statistics. ‘EnviroInfo Vienna, 25 – 27 September 2002’.

A study of back-trajectories for the nine background sites run by the Federal Environment Agency for the years 2000 and 2001 is at present running, which shall investigate the source regions of NO_2, SO_2 and PM10 measured at Austrian background locations.

7 Annex

Description of Austrian monitoring sites (EMEP sites bold)

	altitude	longitude	latitude	start	Topography
Achenkirch	940	11,7003	47,5031	19831001	broad valley
Arnfels	763	15,3678	46,6519	19921028	hilly terrain
Gerlitzen	1895	13,9150	46,6936	19900705	peak
Illmitz	117	16,7656	47,7696	19780501	plane
Klöch	415	15,9567	46,7528	19950801	hilly terrain
Pillersdorf bei Retz	315	15,9422	48,7211	19920201	hilly terrain
Sittmoos	870	12,9506	46,6746	19961219 - 19971211	narrow valley
Sonnblick	3105	12,9583	47,0544	18860901	peak
St. Koloman	1020	13,2333	47,6506	19870501	hilly terrain
Stolzalpe bei Murau	1302	14,2039	47,1292	19911101	slope (SE)
Sulzberg	1020	9,9267	47,5292	19890501	hilly terrain
Vorhegg	1020	12,9719	46,6797	19901211	slope (S)
Zillertaler Alpen	1970	11,8700	47,1369	19880101	slope (N)
Zöbelboden	899	14.4414	47,8386	19930901	hilly terrain

Measurement equipment

Illmitz	Monitoring device
SO_2	1978-01-01 - 1993-12-31: Schenk Sampling Device, Analysed by Spectral Photometry (until 1988) and Ion Chromatography 1991-01-20 - 1991-07-24: TEI 43 1991-10-03 - 1994-05-10: ML 8850 1994-05-01 - 1999-03-15: OPSIS[4] since 1999-03-15: TEI 43CTL
NO, NO_2	1994-05-10 - 1999-03-15: OPSIS (NO_2) since 1999-03-15: Horiba APNA-360E
Ozone	1989-08-29 - 1994-09-26: ML 8810 since 1994-09-26: Horiba APOA-350E
Wet Deposition	WADOS
Particular Sulphate	1978-05-01 - 1995-09-30: Schenk-Sampling Device since1997-02-19: Digitel Low-Volume-Sampler

Enzenkirchen	Monitoring device
SO_2	since 1998-06-03: TEI 43BS
NO, NO2	since 1998-06-03: Horiba APNA-360E
Ozone	since1998-06-03: Horiba APOA-360E

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[4] OPSIS data (SO_2 and NO_2) from Illmitz and Pillersdorf have been withdrawn from the EMEP data base with respect to severe difficulties regarding data capture and calibration

Pillersdorf	Monitoring device
SO_2	1992-02-27 - 1994-11-02: ML 8850 since 1994-11-02: TEI 43S
NO, NO2	1993-05-25 - 1995-10-03: ML 8840 since 1995-10-03: Horiba APNA-360E
Ozone	1992-02-27 - 1993-09-20: ML 8810 since1993-09-20: Horiba APOA-350E

St. Koloman	Monitoring Device
SO_2	1992-02-01 - 1993-06-30: ML 8850S 1999-04-28: TEI 43CTL
NO, NO_2	1990-06-20 – 1993-06-30: ML 8840 1999-04-28: Horiba APNA-360E
Ozone	1990-06-20 – 1997-04-18: ML 8810 1997-04-18 – 1998-03-23: Horiba APOA-350E since 1998-03-23: Horiba APOA-360E

Stolzalpe	Monitoring Device
SO_2	1991-11-01 - 1997-04-29: ML 8850S since 1997-08-06: TEI 43S
NO, NO_2	Horiba APNA-360E
Ozone	1991-11-01 - 1997-04-29: ML 8810 since 1997-08-06: Horiba APOA-360E

Vorhegg	Monitoring device
SO_2	1990-12-04 - 1996-06-05: ML 8850 1996-05-09 - 1999-04-29: OPSIS since 1999-04-29: TEI 43 CTL
NO, NO_2	1994-05-25 - 1996-06-05: ML 8840 1996-06-05 - 1999-04-29: OPSIS (NO_2) since 1999-04-29: Horiba APNA-360E
Ozone	1990-12-04 - 1997-04-29: ML 8810 1997-04-29 - 1998-05-12: Horiba APOA-350E 1998-05-12 - 1998-06-16: Horiba APOA-360 since 1998-06-16: Horiba APOA-350E
Wet Deposition	WADOS, 19.12.1996 – 11.12.1997 in Sittmoos, 12.12.1997 in Vorhegg