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Contents

Summary

This report gives a summary of the work performed by Michiel Roemer during his stay at NILU in summer 1997. The historical record of ozone data for the Norwegian sites were studied to detect significant trends in ambient concentrations over the period 1988-1995. The study revealed discrepancies in trends between three sites (Birkenes, Prestebakke and Jeløya) located in the same region of Norway. This report gives an evaluation of factors that may explain the discrepancy. Finally some recommendations with respect to data quality objectives are given.

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1. Introduction

There is mounting evidence that emissions of NO_x and VOC in various countries in Europe are decreasing over the last years. According to the EMEP emission inventory, NO_x emissions decreased in the order of 10-20% during the period 1989 to 1994 in many countries in NW-Europe (EMEP, 1996). For NMVOC and CO reductions of 12-27% and 10-45% respectively, were reported over the same period. Records of ambient air measurements seem to indicate a similar downward trend of these species in this part of Europe (e.g. EMEP, 1997). However, in order to investigate trends in ozone concentrations, and in particular to link these to trends in precursor emission levels, high quality measurement data are essential.

In a study by Roemer (1997), trend analysis of ground level ozone concentrations in Europe is presented. From this study it can be concluded that the data in some cases may not be of a satisfactory quality to detect trends at the present level of emission reductions, taking into account other factors as e.g. the inter annual variability in meteorological parameters. Even for sites located in the same regions, discrepancies in trends are observed indicating that local factors or measurement errors may have influenced the measurements. In Norway, comparison of results from the sites Birkenes, Prestebakke and Jeløya indicated that such a problem may have existed. The aim of this study is to present time series at the sites and to evaluate factors that may explain the discrepancies observed, i.e. documentation of instruments, calibration, performance, site description, emissions of NO_x and VOC in Southern Norway, time series of SO_2 and NO_2 at Birkenes and Prestebakke, trajectories, meteorological information (wind, clouds, snow cover, radiation) and finally ozone measurements before 1988.

2. Trend results and comparison between the sites Jeløya, Birkenes and Prestebakke

These three sites in southern Norway are located within 190 km (Birkenes-Prestebakke) of each other and could therefore be in one grid cell of the EMEP model (150 km mode). Jeløya and Prestebakke are 80 km apart. It is therefore interesting to look at differences among these three sites, differences, if any, which are unlikely to be resolved by the EMEP model or any other model of this resolution. Trends of ozone at Birkenes and Jeløya are small and not significant at the 95% confidence level. At Prestebakke, ozone concentrations increase quite significantly (just like in Osen and Nordmoen, two other sites not too far away). Table 1 shows the trends of ozone at the three sites under the condition of simultaneous measurements with one of the other sites.

Table 1: Trends (%/yr) of ozone at noon for Birkenes, Prestebakke and Jeløya (rows) under the condition of simultaneous measurements (columns).

1988-1995	with Birkenes	with Prestebakke	with Jeløya
Trend at Birkenes	0.4±1.4	0.2±1.4	-0.1±1.6
Trend at Prestebakke	1.7±1.3	1.9±1.3	1.2±1.8
Trend at Jeløya	-0.6±1.9	-0.5±2.0	-0.4±1.5

Imposing the condition of simultaneous measurement with Jeløya means a drop of about 0.6%/yr. in the trend for the other two sites. Data gaps are relatively large during the first two years (1988 and 1989) at Jeløya. The difference between Jeløya and Prestebakke is prominent in 1988 (up to 20 ppb) and less thereafter, although there seems to be a sort of wave in the difference of ozone in the course of time (Figure 1). A similar finding emerges from the comparison between Jeløya and Birkenes (Figure 2) although the scatter is more abundant. Birkenes is systematically higher than Prestebakke, and this is more or less constant over the 1989-1995 period (Figure 3). In 1988 the difference is about twice as large.

When the year 1988 is left out of the analysis the difference in trend between Jeløya and Prestebakke is less than 0.2%/yr. (both sites with upward trends of about 1.4%/yr.). The difference between Birkenes and Prestebakke is reduced to 0.7%/yr. There is reason to believe that the Jeløya data of 1988 is at least partially influenced by some artefacts.

This example shows that adding or removing one year (on a total of eight) can make quite some difference. Secondly, it shows that there are remarkable difference among sites which are relatively nearby.

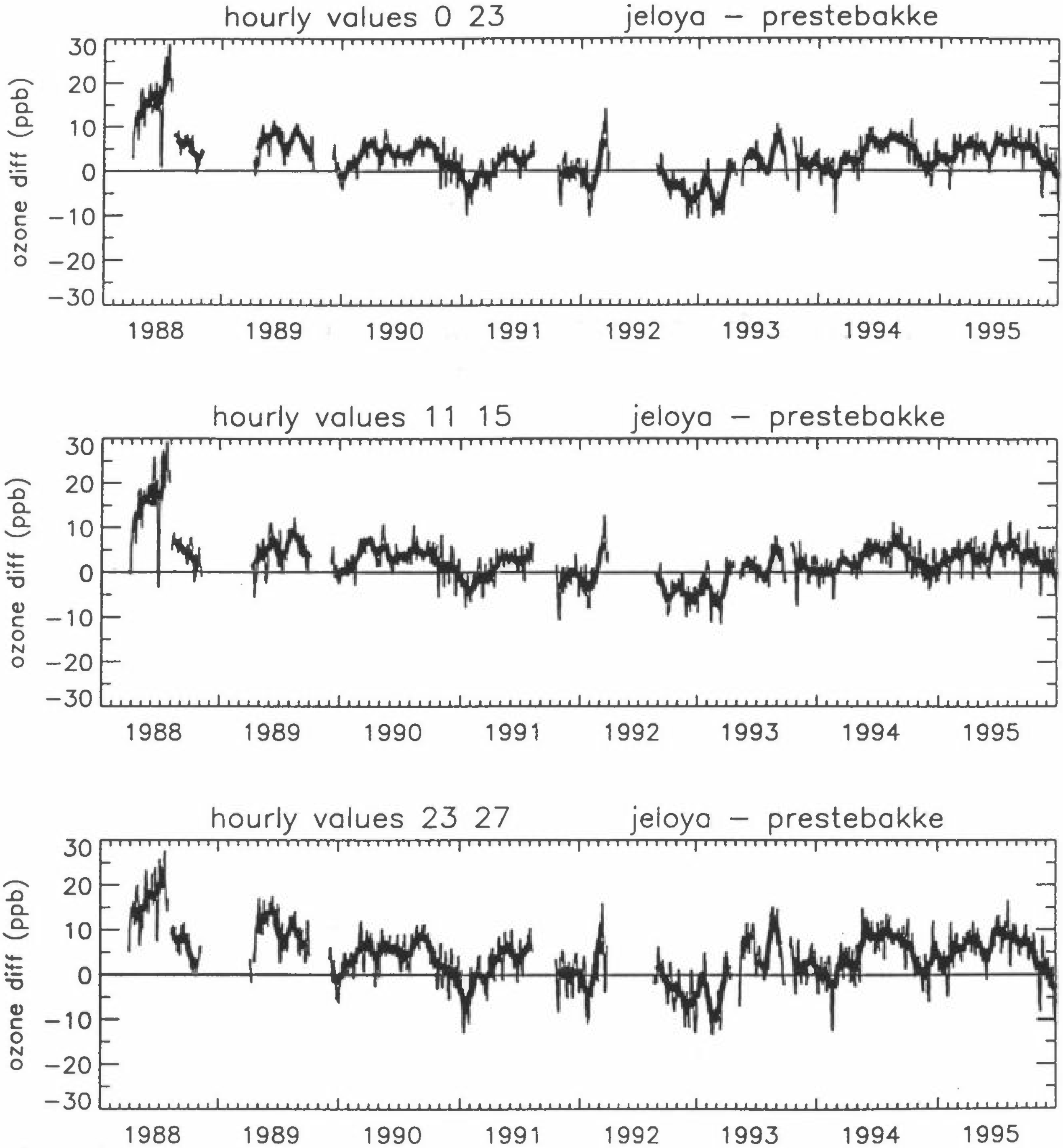

Figure 1: *Weekly (thin line) and monthly (thick line) running average of differences in ozone concentrations (ppb) between Jeløya and Prestebakke. The three panels refer to daily averages, noon averages (11-15h) and midnight (23-07h) averages respectively.*

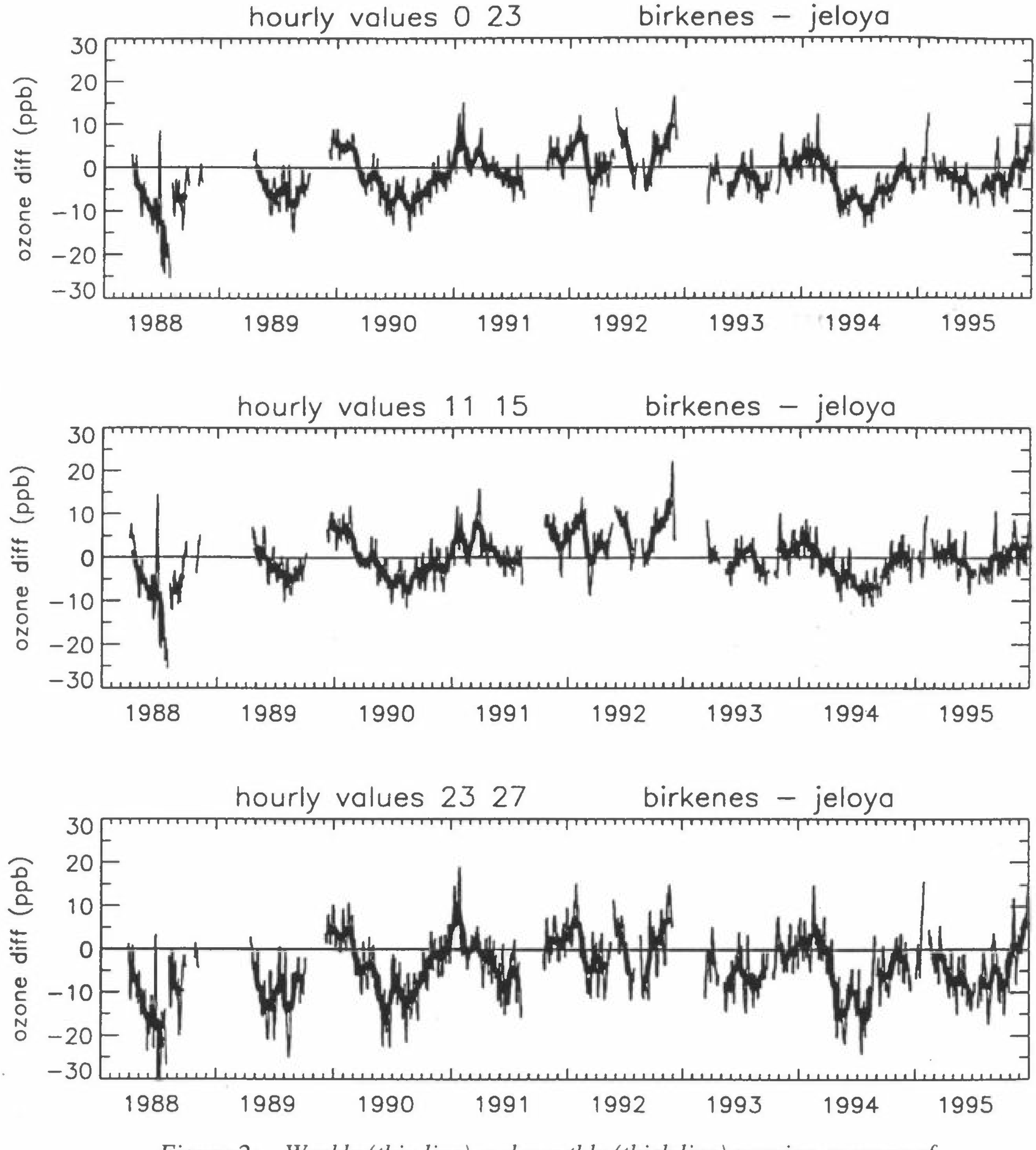

Figure 2: *Weekly (thin line) and monthly (thick line) running average of differences in ozone concentrations (ppb) between Birkenes and Jeløya. The three panels refer to daily averages, noon averages (11-15h) and midnight (23-07h) averages respectively.*

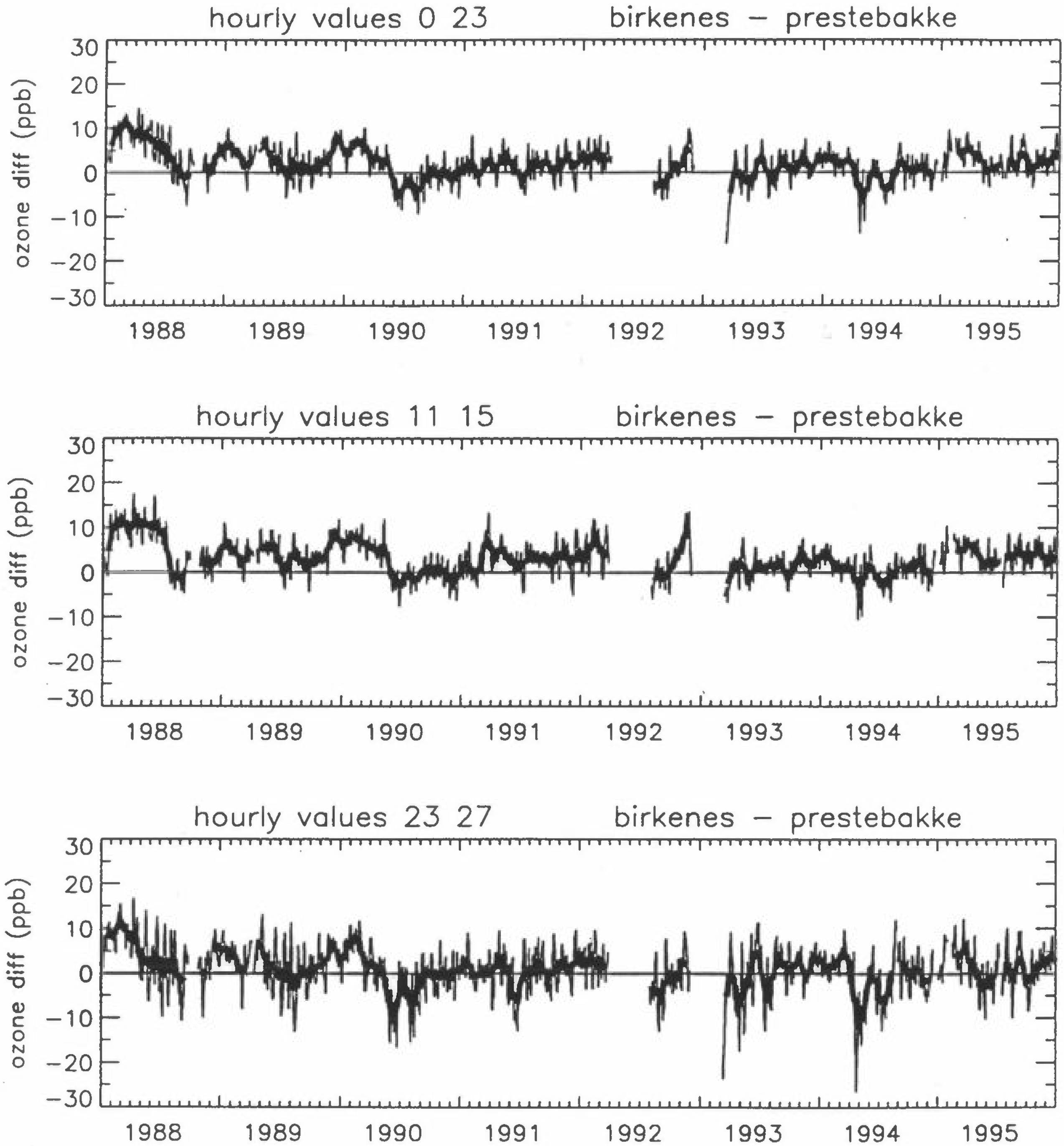

Figure 3: *Weekly (thin line) and monthly (thick line) running average of differences in ozone concentrations (ppb) between Birkenes and Prestebakke. The three panels refer to daily averages, noon averages (11-15h) and midnight (23-07h) averages respectively.*

3. Evaluation of factors that may have influenced historical ozone measurements at the sites

3.1 Documentation of instruments, calibration, performance

The history of the instruments at the sites, the results of the calibrations with the NILU standard as well as the comparison of the NILU standard with the SRP#11 at Stockholm is described in Appendix A. From that the following conclusions are drawn:

- The comparison of the NILU ozone standard monitor with the Standard Reference Photometer (#11) in Stockholm shows a very good agreement. Nevertheless, a difference of about 1.0 ppb between the calibrated NILU standard in the late 1980s and the calibrated NILU standard in 1995 in response to a fixed ozone concentration of 30-40 ppb seems to be the case.
- There are a few comparisons between site monitors and the NILU standard. The Dasibi and the ML site monitors showed in the late 1980s and early 1990s as much as 5-10% underestimation's of ozone concentrations. The comparisons with the API400 site monitors which were installed at Jeløya and Birkenes in 1993 and 1995 respectively showed better agreement with underestimation's ranging from 0-4%.
- Information on the performance of the instrument is given by parameters like span and zero checks which were measured during site visits once every three months in the late 1980s and early 1990s. Although the span check show decreasing values, this is not necessarily because of reduced response, but due to changes in the internal source.
- The performance of the inlet filter and how it might have affected the measured ozone is not clear. The Teflon filter might get polluted with pollen, soot and other aerosols which potentially remove ozone. Due to the relatively low ambient concentrations of these particles, it assumed that other explanations are more likely.

3.2 Site description

Site descriptions are given in Hagen et al. (1990). The following remarks apply:

- At Jeløya there are no major obstacles blocking advection to the site at southerly wind direction. The site is located on the southern island in the outer Oslofjord area. With easterly or south westerly wind, local emissions of NO_x may influence the measurements.
- Both Birkenes at Prestebakke are located in forested areas. The Birkenes site is placed in an open field, but may be subject to some influence of a forest section in south/south-westerly direction at about 100 m distance. Prestebakke is located in a forest and is likely to be subject to reduced exchange of air with the layers aloft in many situations.
- The inlet height of the samplers is approx. 2 m above ground level.
- No major changes in the site surrounding are known to have happened over the study period.

3.3 Emissions of NO_x and VOC in Southern Norway

In this study, EMEP emissions of 1994 on a 50x50 km2 grid were used. Annual NO_x emissions in southern Norway vary between 5-10 kton NO_2 per grid cells in the 6 respective cells covering the Oslofjord area. The NO_x emissions in the grid cells hosting Prestebakke and Birkenes are lower (1-5 kton NO_2 eq./yr). It should be noted however, that sources at the Swedish west coast may be expected to have a significant contribution to ambient concentrations in the area. A similar picture emerges from the NMVOC emissions in this area. Annual emissions of 5-10 kton NMVOC in six the 6 grid cells in the Oslo fjord area (including Oslo). The grid cells with Prestebakke and Birkenes emit 1-5 kton/yr. of NMVOC. The emissions include natural emissions.

3.4 Time series of SO_2 and NO_2 at Birkenes and Prestebakke

SO_2 and NO_2 are measured at Birkenes as daily averages. At Prestebakke NO_2 is measured as daily averages whereas SO_2 is measured as two-daily or three-daily averages in a rhythm that makes three samples per week (2+2+3). Figure B1-4 show the time series of SO_2 and NO_2 at Birkenes and Prestebakke for 1988 and of SO_2 for 1995.

SO_2 levels in 1988 were much higher than in 1995 at both sites which is obviously a result of stringent emission reductions in many parts of Europe.

The time series at Birkenes and Prestebakke correlate quite well with each other, both for SO_2 and NO_2. There are occasions with marked differences which could be due both to local sources as well as to differences in long range transport. However, the duration of pronounced differences is usually limited to a few days. There is no indication from the SO_2 and NO_2 measurements that Prestebakke and Birkenes have experienced influence of different air masses for a long period of time, not in 1988 and not in 1989 and 1995. The records suggests that both sites probably have very similar composition as far as it concerns precursors. The records also suggest downward trends of NO_2 concentrations at both sites.

3.5 Trajectories

96 hours back trajectories calculated once every six hours (0, 6, 12 and 18h) were allocated in 5 five different sectors (50-150°, 150-220°, 220-260°, 260-310° and 310-50°) representing respectively air masses from Russia and Eastern Europe, Western and Southern Europe, the UK, the Northern Atlantic and the Arctic. A back trajectory was allocated in a sector when it spent at least of 50% of its time in this sector during the four days before arriving at the receptor point. The location of the last 150 km of the trajectory is not considered in the allocation analysis. If the trajectory stays less than 50% of the time in a sector it is considered as undefined. For the three sites concerned back trajectories for 1988 and 1989 were compared. In 1988 as well as in 1989 in about two-third of the occasions trajectories were allocated in the same sector at all three sites, indicating that during these occasions all three sites have been influenced by the same large scale advection. A closer inspection shows that there were no shorter periods (of a few months) with much more occasions of differences in sector allocations.

The occasions that all three sites did not have similar sector allocation of the trajectories were usually characterised by Birkenes being different from the other two, Jeløya and Prestebakke. However, it should be noted that the meteorological model used for sector allocation have a resolution of 150x150 km^2, and will not reflect local meteorological conditions. Even regional estimates will have large uncertainties.

3.6 Meteorological information (wind, clouds, snow cover, radiation)

No meteorological measurements are made on the measurement sites, but may be inferred from the national meteorological network. This information has not yet been collected.

3.7 Ozone measurements before 1988

The data base contains ozone records going back to 1980 (Langesund and Jeløya). Until 1985 the ozone measurements covered the growing season (April-September), in 1986 and 1987 Prestebakke and Birkenes started to measure ozone all year round. Differences between Birkenes and Prestebakke were relatively small in 1986 (the histogram of hourly differences being close to a Gaussian curve with the 50-percentile at 0 ppb). In 1987 ozone concentrations at Birkenes seem to be on average about 5 ppb higher than in Prestebakke. The differences between the two sites are however not as large as in 1988. Considering the histograms of hourly differences of ozone concentrations between Birkenes and Prestebakke it appears that for all years except 1987-1989 this histogram is symmetric with the 50-percentile close to 0 ppb. In 1987 and 1989 the majority of hourly differences is between 0 and 10 ppb more ozone in Birkenes and in 1988 it is between 0 and 15 ppb more ozone in Birkenes. Differences between Jeløya and Prestebakke are more variable, but in general ozone concentrations in Jeløya are 0-10 ppb higher than in Prestebakke. In 1988 the differences between the two sites were extreme. The histogram of hourly differences shows almost equal distribution in a wide range from 0-30 ppb. The two previous years 1986-1987 also show large discrepancies between Jeløya and Prestebakke, but not as extreme as in 1988.

4. Discussion

There are various sources that might have contributed not only to differences between the ozone concentrations at the three sites but also to differences in trends. From the trend analysis it was clear that a substantial contribution to the trend in Prestebakke being different from the trends in Birkenes and Jeløya (and Rörvik) came from the year 1988 with relatively low ozone concentrations in Prestebakke. From the collected information it seems that the following elements can most probably be excluded as explanation for the discrepancies:

1. *Calibration of the ozone standard at NILU.* There are differences between the NILU standard and the SRP#11 in Stockholm, and they are not constant in time, but the differences are small. Moreover, it should apply on all three sites similarly, if there were no other causes for discrepancies.

2. *Long range transport.* Birkenes and Prestebakke experienced in 1988 and 1989 more than 2/3rd of the time simultaneously air from the same sector, and for Jeløya and Prestebakke this fraction is even higher. This allocation of trajectories into sectors does not show much variation in the course of one year. The distribution of trajectories over the sectors indicates no contribution to trend discrepancies due to long range transport.

3. *Chemistry.* The NO_2 and SO_2 measurements show that the chemical composition at Birkenes and Prestebakke have been much the same during most of the time. Large discrepancies between the two sites usually last for just a few days. Correlation's of SO_2 and NO_2 concentrations between the two sites in 1988 were about the same as in 1989 or in 1995. The emissions of NO_x and NMVOC at a 50x50 km^2 resolution support the idea that local chemistry has likely not been the cause for discrepancies between Prestebakke and Birkenes. Jeløya might have been affected more than the other two sites by local chemistry.

From the ozone observations it is clear that the factors that have contributed to the discrepancies have done so for at least a few consecutive months. It is not very likely that this concerns meteorological factors like cloudiness and radiation. These factors can be highly variable in space and time but probably not in a way that might have affected the ozone concentrations as seen in data records. Snow cover can affect ozone concentrations by blocking dry deposition and this lasts as long as there is snow. This element has not yet been investigated and cannot be excluded at the moment.

Two elements remain: land use in site surroundings and instrumental artefacts. Both Prestebakke and Birkenes are located in a forested areas and may therefore be subject local deposition effects or atmospheric perturbation. Ozone concentrations in Prestebakke were, compared to Birkenes and Jeløya (and Rörvik) particularly low in 1988. However, no major changes in land use in the vicinity of the sites are known to have happened. The years with the largest systematic differences between Prestebakke and Birkenes were 1988 followed by 1987 and 1989. However, 1986 showed little difference between the two sites.

The last element in the discussion is the performance of the site instrument. The logbooks describe one calibration (April 1989) of the Birkenes site monitor before 1995, no calibrations with the Prestebakke site monitor and two calibrations (July 1991 and August 1992) at Jeløya. All three calibrations show underestimation of ozone concentrations by the site monitor with 5-10%. The only other indication of the performance of the instrument is by the span and zero checks. The span values usually decreased in the late 1980s and early 1990s with 10-20% in the course of one year. In conjunction with the results of the few site calibrations this suggests a reduced sensitivity of the monitor span.

In later years, and especially in the last two years, the checks on span and zero and on other parameters were done much more frequently (up to once every week) and the stability of the span parameter is much better (decreases limited to a few percent). There have been three calibrations with the Birkenes site monitors in 1995, one with the Jeløya site monitor (Feb. 1996) but no calibrations with the

Prestebakke site monitor. The four more recent calibrations show much better agreement with the NILU standard, ranging from virtually no difference to an underestimation of ozone concentrations by the site monitor with a few percent.

This information suggests that there are blocks of data before about 1994 which might be underestimates of the ambient ozone concentrations with as much as 5-10%. In 1994 and 1995 the performance of the instruments was better and underestimates, if any, probably smaller. It is not hard to see that if the data is truly 'contaminated' by instrumental drifts it will create an artificial trend (1988-1995) that might be as large as +1% per year. At the moment the information is suggestive, and not a hard proof. It does however show that we can not exclude the explanation that in one year (1988) the measurements at one of the sites have been particularly influenced by instrumental drifts.

In addition, the effect of possible pollution of the inlet filter is hard to quantify. The inlet filters were replaced every three months. It is not sure how much the filters were polluted (with pollen, soot or other aerosols) and how much this might have affected the ozone concentrations.

5. Conclusions

The objective of this work was to see if the difference in ozone trend (1988-1995) at Prestebakke (compared to trends at Jeløya, Birkenes and Rörvik) could be explained by local conditions, or instrumental behaviour or differences in long range transport. It is concluded:

- that the differences in trend can not be attributed to variations (in space and time) of long range transport and/or local chemistry.
- that the performance and stability of the NILU standard is good enough to ensure a proper reference to the site monitors.
- that information on land use in the site surroundings need to be examined to assess their possible role in the trend discrepancies.
- that the information from the logbooks suggests possible underestimation of ozone concentrations during certain blocks of time, especially in the earlier years. There is no indication that this has affected especially Prestebakke, but it can not be excluded either. Since it concerns all three sites (but perhaps not in the same way) there is reason to believe that the actual trend differs from the trend as derived from the measurements by some unknown factor or term.

6. Recommendations

Since the changes in ozone concentrations due to European emission changes (reductions) are expected to be small, the requirements on the data collections demand the highest possible quality of the data and as little influence from nearby sources and land use as possible.

The checks and regular calibrations of the site monitor should ensure stability of the monitor within 1% of the reference (provided that the reference is good).

Possible interference of ozone with pollution on the inlet filter should be traceable in the first place, made quantitative in the second place and limited to less than 1% in the third place.

The site should be free from nearby obstacles in all directions. Guidelines about what this means in terms of radius of clearance should be developed. The land use of the nearby surroundings should remain constant in time.

The site should be free from nearby sources as much as possible. Continuous measurements of ozone precursors together with emission data can be very helpful in analysing the ozone records and possibly removing influences from nearby sources.

In addition, meteorological information like trajectories, local meteorology, snow cover and radiation is recommended to include in evaluating the ozone records.

Finally, a second ozone station within 50-100 km and subject to the same requirements as the first station is recommended as a check on the data.

7. References

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Appendix A

History of instruments, calibration, site description

History of the instruments

Logbooks at NILU describe the history of the instruments. This description becomes more detailed in the course of time. In the late 1980s and early 1990s the instruments were usually checked once every three months (amongst others to change the Teflon inlet filter). The checking included measuring the sample and control frequency of the UV lamp, temperature and pressure in the measurement cell, and the calibration span and zero. In later years these checks were performed automatically and remote. In 1995 the logbook contains weekly checks of the instruments.

In the following sections a summary of the history of the instruments at Birkenes, Prestebakke and Jeløya over the 1988-1995 period will be given. The focus is on the calibration span and zero values since these are the parameters that give information on the performance of the instrument.

Birkenes

October 1987. The ozone monitor at Birkenes is a Dasibi RS1008, SN4275 (series number)

Of this instrument there are no calibration curves available (for this period) in the logbook.

date	span check	zero check	remarks	
26-11-1987	103	14		
22-03-1988	90	15 ?		
23-03-1988	93	14		
30-06-1988	93	12		
26-10-1988			instrument back from NILU to Birkenes	
15-11-1988	87	11		
10-04-1989			calibration instrument at NILU	
			1008 RS (Birkenes)	NILU standard
			8	9
			38	41
			57	62
			70	78
			96	105

The instrument at Birkenes measures 6-8% lower than the NILU standard. After the calibration the Birkenes monitor has been adjusted.

13-04-1989	105	9	
27-07-1989	100	9	
23-10-1989	80	10	
25-10-1989	93	9	
12-11-1989	85	10	(new scrubber inserted)
28-03-1990	88	11	
11-10-1990	86	10	
12-03-1991	96 (30 min.)	10	(new scrubber)
02-10-1991	100	11	

12-02-1992	96	11	
05-05-1992	104	10	(silver scrubber inserted)
26-05-1992	119	10	(new lamp)
22-09-1992	99 (25 min.)	11	
12-02-1993			instrument does not work

At March 1993 (09-03-1993) the Dasibi is replaced by a Monitor Labs 8810 instrument, SN1134. No calibration curves found in the logbook.

09-03-1993	107	0

In general instrumental checks are made once every 2 weeks. Sometimes it is once every week, sometimes once every month. There is little variation of the value of the calibration span during the almost 2 years with the ML instrument. It gradually decreased from 105-107 in the beginning of 1993 to 97-99 at the end of 1994.

In January 1995 the Monitor Labs ozone analyser is replaced by an API 400 ozone analyser, SN214. Calibration curves of this and other SN instruments are available in the logbooks.

05-01-1995	start SN214 at Birkenes	
	result of calibration at 27-04-1994	
	SN214 = 0.992 * NILU standard -	6.643 µg./m³
	st.deviation slope:	0.012
	st.deviation deviation intercept:	2.326 µg./m³
31-01-1995	stop SN214 at Birkenes	
15-02-1995	start SN213 at Birkenes	
	result of calibration in late 1995	
	SN213 = 0.999 * NILU standard -	0.339 ppb
	st.deviation deviation slope:	0.002
	st.deviation deviation intercept:	0.167 ppb
13-07-1995	stop SN213 at Birkenes	
13-07-1995	start SN376 at Birkenes	
13-07-1995	SN376 returned to NILU	
18-07-1995	start SN401 at Birkenes	
	result of calibration at 17-07-1995	
	SN401 = 0.999 * NILU standard -	0.760 ppb
	st.deviation deviation slope:	0.007
	st.deviation deviation intercept:	0.524 ppb
31-12-1995	SN401 still runs at Birkenes	

Prestebakke

10-10-1987 A Dasibi RS1008, SN4229 runs at Prestebakke, there are no calibration curves available in logbook.

date	cal. span	cal. zero	remarks
19-11-1987	105 -> 110	10	
05-01-1988			pump does not work
01-06-1988	104	12	
21-09-1988	120	11	
15-11-1988	125	11	
02-12-1988	120	13	
06-12-1988	110	6	
26-07-1989	115	12	
20-12-1989	-		before inspection
20-12-1989	133	10	after inspection
08-01-1990	120	9	
18-05-1990	118	12	before inspection
18-05-1990	137 ?	10	after inspection
15-10-1990	122	12	
06-12-1990	127	9	
18-12-1990	135	9-10	
05-03-1991	134	9	
21-03-1991	119	11-12	
26-09-1991	107	10	
11-12-1991	108	7	
28-04-1992	106 (5 min.)	10	
27-08-1992	106	11	
12-02-1993	118	11	

In March 1993 a Monitor Labs instrument is installed at Prestebakke (ML 8810, SN1150), checks are made usually at intervals between 1 week and 1 month.

24-03-1993	140	0
16-04-1993	136	-1
26-04-1993	131	-1
09-09-1993	116	0
10-09-1993	123	0
27-09-1993	124	0
......		
30-11-1993	126	0
01-12-1993	126 -> 117	0
02-03-1994	122	0
03-03-1994	118	0
27-04-1994	110	0
21-06-1994	104	0
30-11-1994	109	0
......		
26-04-1995	109	0
......		
23-11-1995	108	0

At the end of 1995 the ML8810, SN1150 was still running at Prestebakke.

Jeløya

The type of instrument used at Jeløya before 1991 is not clear. The logbook mentions a DASIBI 1008 AH (?), SN4088 at 07-03-1991. For the moment it is assumed that this instrument has been in operation before that time too.

date	cal. span	cal. zero	remark
04-12-1989	133	0	
08-01-1990	139	0	
18-04-1990	104	1	
04-05-1990	106	0	
15-10-1990			no information is given in the logbook, though there has been a site visit.
07-03-1991			no information is given in the logbook, though there has been a site visit.
05-06-1991			ML8810,SN386 is taken to Jeløya. The Jeløya ozone monitor produces 5-6 units (ppb !??) lower than the ML, which then is the NILU standard (?).
19-08-1992	115	0	calibration at NILU. Jeløya instrument produces 8-11 units (ppb!??) lower than the NILU standard.
19-10-1992	115	0	
10-05-1993			a new ozone monitor is established, the API 400, SN93.
10-05-1993 until 10-08-1993			the logbook refers to data as test measurements. There is data of this period in the database.

08-10-1993 calibration of the instrument

API93 = 0.992 * NILU standard + 0.220 ppb

st.deviation deviation slope: 0.002

st.deviation deviation intercept: 0.218 ppb

checks are made at intervals between once every week and once every month. Between February 1995 and July 1995 the calibration span gradually decreased from 206 to 198 and calibration zero decreased from 1.7 to 0.5. In October 1995 the same parameters varied between 212 and 203 and between 0.8 and 1.4 respectively.

29-02-1996 calibration of the instrument

API93 = 0.959 * NILU standard + 0.243 ppb

st.deviation deviation slope: 0.004

st.deviation deviation intercept: 0.389 ppb

Calibration

At NILU there is an ozone instrument that is used as the standard to calibrate the other ozone monitors. This instrument itself has been calibrated against the SRP#11 (Standard Reference Photometer, number 11) which is kept in Stockholm.

At September 30, 1987 this SRP#11 has been examined by the National Bureau of Standards in the United States. The accuracy of the instrument fundamentally depends on the estimate of uncertainty with which the ozone absorption coefficient is known at 253.7 nm (308.32 cm^{-1} atm^{-1} ± 1.5%). The accuracy of the SRP#11 has been characterised by the following :

range 0- 100 ppbv uncertainty ≤ 1.0 ppbv
range 100-1000 ppbv uncertainty ≤ 1%

the standard deviation of 20 repetitive measurements of a fixed ozone concentration is 0.4 ppbv over the 0-1000 ppbv range.

The interval at which NILU sends their standard to Stockholm is about 18 months. The following records were found in the logbooks.

30 March 1993
guest: NILU Dasibi SN3465 (1008 PC)
guest = 0.997 * SRP#11 -0.6 ppb
st.deviation deviation slope: 0.0048
st.deviation deviation intercept: 0.0192 ppb

24 November 1993
guest = NILU Dasibi SN3465 (1008)
guest = 1.0127 * SRP#11 + 0.39 ppb
st.deviation deviation slope: 0.003
st.deviation deviation intercept: 0.331 ppb

1 February 1995
guest = NILU LS ML 9811 (SN459)
guest = 1.0060 * SRP#11 -0.15 ppb
st.deviation deviation slope: 0.003
st.deviation deviation intercept: 0.377 ppb

18 October 1995
guest = NILU LS ML 9811 (SN459)
guest = 1.0137 * SRP#11 - 0.14 ppb
st.deviation deviation slope: 0.002
st.deviation deviation intercept: 0.347 ppb

7 July 1997
guest = NILU LS ML 9811 (SN459)
guest = 1.0137 * SRP#11 - 0.34 ppb
st.deviation deviation slope: 0.001
st.deviation deviation intercept: 0.185 ppb

Table A1 shows the response of the NILU standard to fixed ozone concentrations in the range of 10-120 ppb according to the different calibrations. The largest differences are found (Table A1) between the first calibration in 1989 and the second in 1993. In the range of 30-40 ppb, which is about the average ozone concentration at the sites, the maximum difference in the calibration is about 1.5 ppb. At high ozone concentrations the difference increases to 2.5-3 ppb. Between the last three calibrations the difference is less than 0.3 ppb below 40 ppb and less than 1.0 ppb at 120 ppb.

Table A. 1: Table 1 History of calibration of NILU standard with SRP#11.

ozone (ppb)	30.03.89	24.11.93	01.02.95	18.10.95	07.07.97
10	9.37	10.52	9.91	10.00	9.80
20	19.34	20.64	19.97	20.13	19.93
30	29.31	30.77	30.03	30.27	30.07
40	39.28	40.90	40.09	40.41	40.21
50	49.25	51.03	50.15	50.55	50.35
60	59.22	61.15	60.21	60.68	60.48
70	69.19	71.28	70.27	70.82	70.62
80	79.16	81.41	80.33	80.96	80.76
90	89.13	91.53	90.39	91.09	90.89
100	99.10	101.66	100.45	101.23	101.03
110	109.07	111.79	110.51	111.37	111.17
120	119.04	121.91	120.57	121.50	121.30

Appendix B

Figures

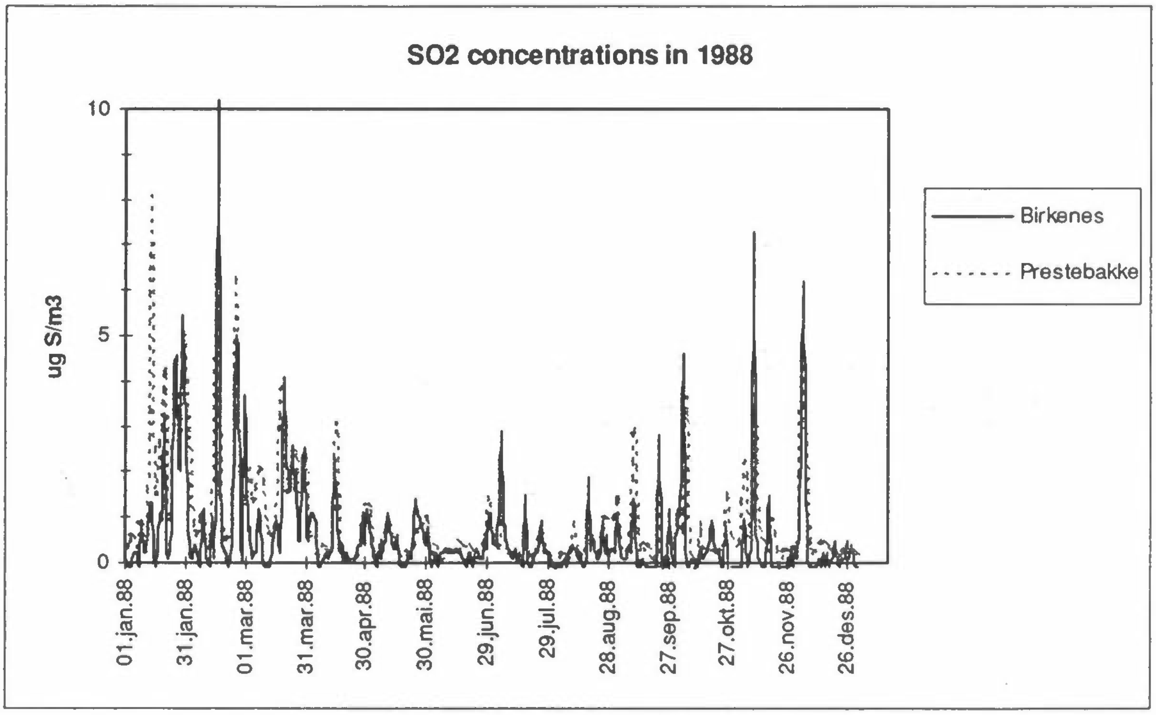

Figure B1: SO_2 concentrations (μg S/m^{-3}) at Birkenes (daily average) and Prestebakke (2 or 3 daily averages) in 1988.

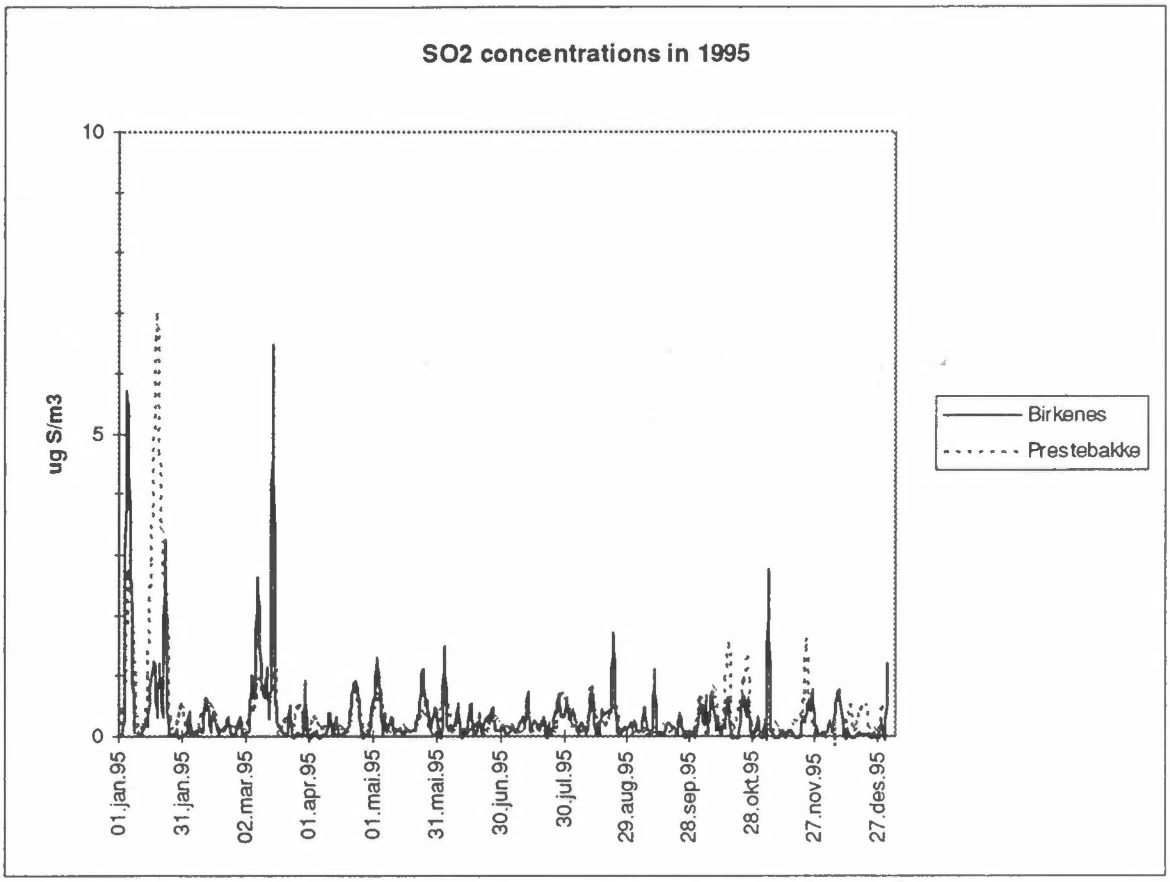

Figure B2: *SO_2 concentrations (μg S/m-3) at Birkenes (daily average) and Prestebakke (2 or 3 daily averages) in 1995.*

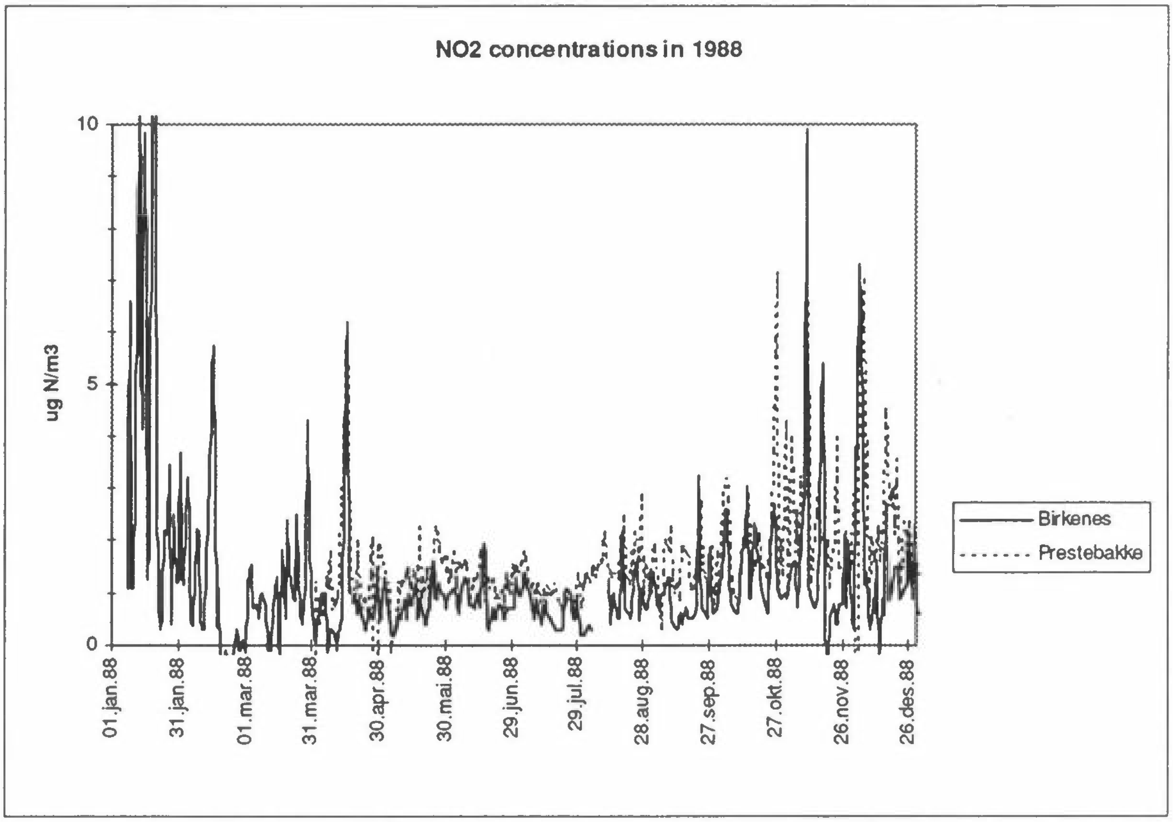

Figure B3: *NO_2 concentrations (µg S/m-3) at Birkenes (daily average) and Prestebakke (daily average) in 1988.*

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ABSTRACT

This report gives a summary of the work performed by Michiel Roemer during his stay at NILU in summer 1997. His study revealed discrepancies in trends between three sites (Birkenes, Prestebakke and Jeløya) located in the same region of Norway. This report gives an evaluation of factors that may explain the discrepancy. Finally some recommendations with respect to data quality objectives are given.

NORWEGIAN TITLE

Evaluering av ozon måledata ved stasjonene Birkenes, Jeløya og Prestebakke

KEYWORDS		
Ozone	Monitoring	Calibration

ABSTRACT (in Norwegian)

Historiske ozondata har vist ulike utviklingstendenser mellom tre nærliggende stasjoner (Birkenes, Prestebakke og Jeløya). Rapporten evaluerer ulike faktorer som kan ha forårsaket de avvikende trender.

* *Classification*	*A*	*Unclassified (can be ordered from NILU)*
	B	*Restricted distribution*
	C	*Classified (not to be distributed)*