Measurements of total ozone 2003-2005

Weine Josefsson

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Avtal Nr. 211 0405 Dnr. 721-1511-04Mm
Programområde Luft, Delprogram Ozonskiktet

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1. Introduction

The purpose of this report is to summarize the ozone monitoring project for the period 2003-2005. The measurements are done by SMHI within the Swedish national environmental monitoring, which is funded by the Swedish Environmental Protection Agency. The status of the involved instruments is described briefly. Performed calibrations and their results as well as test data are reported. Measured daily data are plotted, listed and shortly commented.

2. General comments

The total ozone is measured at two sites. In Norrköping on a platform on top of the roof of SMHI located at 58.58°N 16.15°E 43m and at Svartbergets försökspark in Vindeln at 64.24°N 19.77°E 225m, regular monitoring started in 1988 and 1991 respectively. Responsible for the project and the monitoring at Norrköping is Weine Josefsson and in Vindeln Mikaell Ottosson Löfvenius.

At Norrköping the total ozone is measured by a Brewer ozone spectrophotometer #128 Mk III. In Vindeln there is also a Brewer ozone spectrophotometer #006 Mk II since 1996, but also a Dobson ozone spectrophotometer #30. The latter is the same instrument that was used in Uppsala in the period 1951-1966.

The total ozone data from Uppsala have been used as a reference both for Norrköping and Vindeln. The yearly average course of daily total ozone and the corresponding daily standard deviations can be seen in the yearly plots presented in this report.

A brief description of quality control, quality assurance and measurements of total ozone at Norrköping and Vindeln for the years 2003, 2004 and 2005 is reported in the following chapters. Specific events that may have affected the monitoring are compiled in Appendix A. Those compilations indicate the complexity of the monitoring and points at the need of daily maintenance. Efforts are spent to minimize breaks in measurements and if they occur they should be as short as possible. The lists are also useful to consult in case something odd appears in the analysis.

Plots of the daily data, see figures in chapter 5, and the daily standard lamp test values, figures in chapter 4, are shown. Monthly values of total ozone for all years are presented in Appendix B and daily values for the years 2003-2005 in Appendix C. Older values and instrument status are reported in several reports see Chapter 7.

All Brewer values refer to Bass-Paur scale and are traceable to the Brewer Triad kept at Meteorological Service of Canada in Toronto via the traveling reference Brewer #017. International Ozone Services (IOS) operates Brewer #017 and makes calibrations roughly every third year on the Swedish Brewer instruments #006 and #128. The results are compiled in Appendix D for both instruments. The Dobson total ozone values also refer to the Bass-Paur scale. They can be traced back to the world standard Dobson #83 for Dobson total ozone measurements via the regional standard Dobson #104 kept in Hohenpeissenberg.

Data are regularly sent to the WOUDC (World Ozone and Ultraviolet Data Centre) about once a month. In case of eventual corrections to data they are re-submitted. Therefore, the data kept at WOUDC should agree with the data kept at the national data centre at SMHI in Norrköping. The latter data as well as graphs are also freely available on the web site of SMHI (www.smhi.se), which is updated about once a week.

3. International use of data

Data has been used for validation of satellite algorithms for total ozone. The recent European SCIAMACHY-instrument on board the satellite ENVISAT has been validated using data from Norrköping and Vindeln see for example:
http://www.temis.nl/protocols/validation_tosomi_25032004.pdf
http://www.copernicus.org/EGU/acp/acpd/5/4429/acpd-5-4429_p.pdf

Data from the parallel measurements of the total ozone using the Brewer and the Dobson spectrophotometers has been used in the study of Staehelin et al (2003), see Chapter 4.3. Interestingly, the results from Vindeln differ significantly from the results of mid-latitude stations. The cause of the difference is not yet clear. This points at the value of high quality measurements at high latitude sites.

4. Instrument status

4.1 Brewer #128

The latest comparison of Brewer #128 was done at the site in Norrköping in 2003. The change relative the previous comparison in the year 2000 was not so large. These and older comparisons are compiled in Appendix D.

The standard lamp test is done daily by measuring towards an internal halogen lamp in the same way as one make observations of the total ozone. This test is very sensitive for changes of the relative spectral responsivity that can have severe effects on the observations, see Figure 4.1. Changes in the relative sensitivity between the radiance measured at the selected wavelengths for ozone observations is measured and can be expressed as a ratio called R6. In principle, corrections to the measured total ozone, TOZ_{uncor}, can be applied directly by

$$TOZ_{cor} = TOZ_{ucor} + (R6_{ref} - R6) / (\mu * 10 * \alpha),$$

where the corrected total ozone, TOZ_{cor}, can be deduced by inserting the observed daily standard lamp test value R6, the $R6_{ref}$ value which was measured and established at the last intercomparison, the relative optical airmass valid for the ozone layer, μ, and the differential ozone absorption coefficient α (=0.3491 for Brewer #128).

The result of the standard lamp tests over the years since 1999 indicates that gradual and sometimes large changes of the relative spectral responsivity have occurred. Since the last intercomparison in 2003 the R6-value has decreased roughly by 15 units at the end of 2005. This corresponds to about 2 DU, which should be added. This small correction will not be applied until after the next intercomparison, which is planned to take place in May or June of 2006. Retro-perspective corrections based on these results will then be applied to the total ozone data followed by resubmission of data to WOUDC.

Another interesting feature that can be observed in Figure 4.1 is the seasonal variation for several years in the past. It have apparently disappeared after the last comparison in 2003 when a new set of temperature coefficients were introduced.

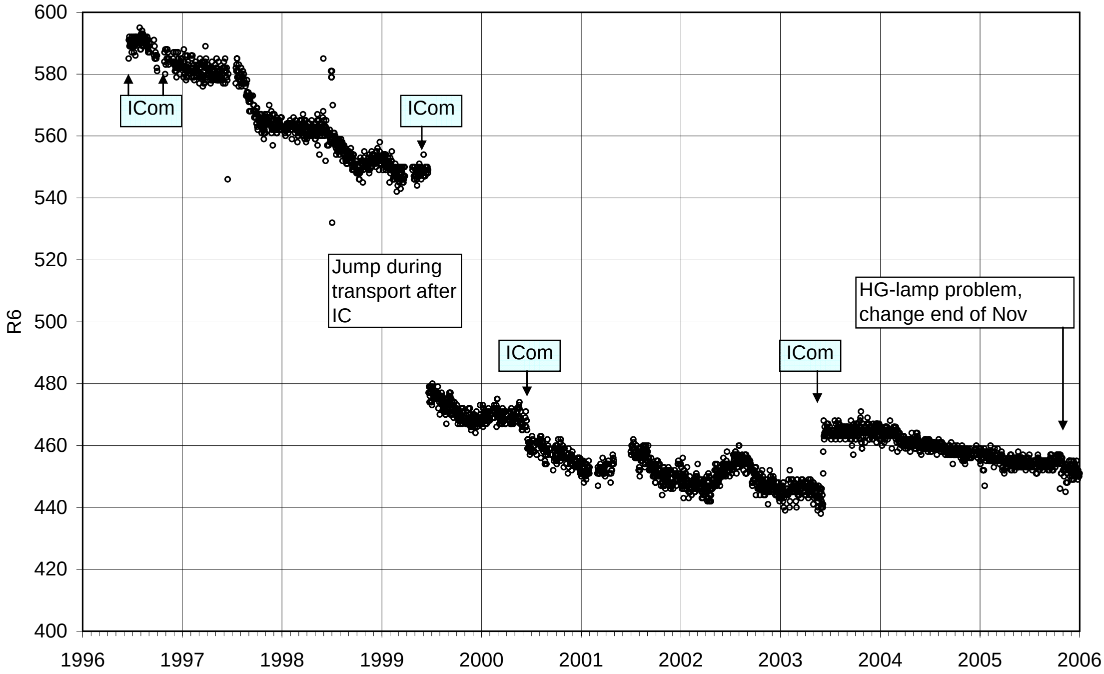

Figure 4.1 Standard lamp test value R6 for Brewer #128 over the period 1996-2005. The large change after the calibration in 1999 is clearly seen. Times for intercomparisons are noted as well as lamp changes.

Another test of state of the Brewer is the so called dead-time test. A photomultiplier (PM) is used to measure the radiance. A counting system tries to count the impinging photons. When a pulse is detected the counter must wait a moment for another pulse to be detected. This time interval is called the dead-time. However, even at low count rates there is a probability that two photons arrive very close in time and thus cannot be distinguished. This causes a non-linear response. Assume that the time interval distribution of arriving photons follow a Poisson distribution. The probability, Po, that a pulse overlaps with another pulse inside a certain time interval, is given by

$$Po = 1 - \exp(-N^*\tau)$$

where τ is the dead-time and N is the count rate. The true count rate N_0 can be found by iteration of $N=N_0^*\exp(-N^*\tau)$. This correction is applied for all measurements of the Brewer and is thus sensitive for the value of τ. The dead-time test gives information on the temporal development of the dead-time, Figure 4.2. It is measured at two levels of radiance presented by blue (right) and red (left scale) dots. It can be seen that the dead-time has slowly decreased from about 43 ns to about 39 ns over the period 1997 to 2006.

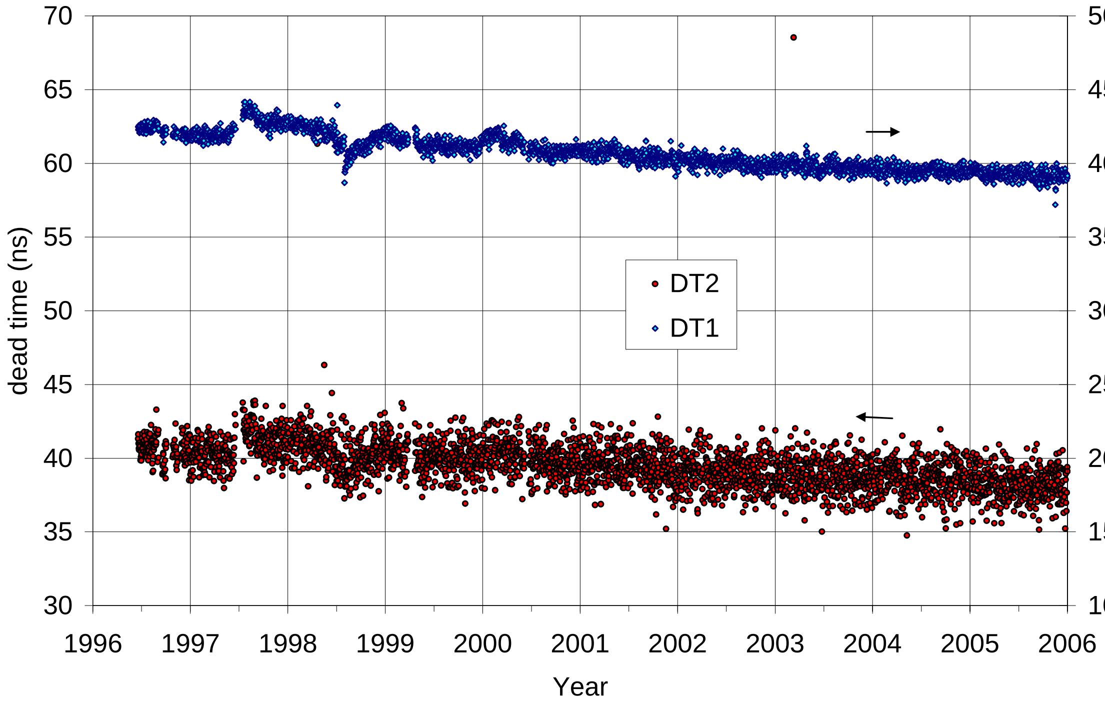

Figure 4.2. Dead-time for Brewer #128.

In front of the photomultiplier tube (PMT) there is a plate with the exit slits of the spectrometer. The spectrum produced by the gratings is projected over the exit slits. To prevent the exposure of the PMT for the radiance of all wavelengths at the same time there is a shutter mask in front of the slits. This mask moves up and down in cycles exposing one slit a time. One cycle takes about one second. Typically, a single measurement of total ozone uses 20 cycles. The average photon counts for each slit (wavelength) of the 20 cycles can be regarded as recorded simultaneously.

The mask moves very rapid and the photon counting must be done when each slit is exposed. This demands a good synchronization. A special test is done to check this. It is called the run and stop test, Figure 4.3. Using the internal standard lamp a measurement is taken with the mask moving. The next step is to do the same measurement stopping the mask at each slit. Then the ratio between the two measured photon counts is computed. This ratio should be 1 within an uncertainty of ±0.002. If not the synchronization must be adjusted. The parameter to do this is called the shutter delay time. The outliers in Figure 4.3 are probably due to random disturbances in the measurements.

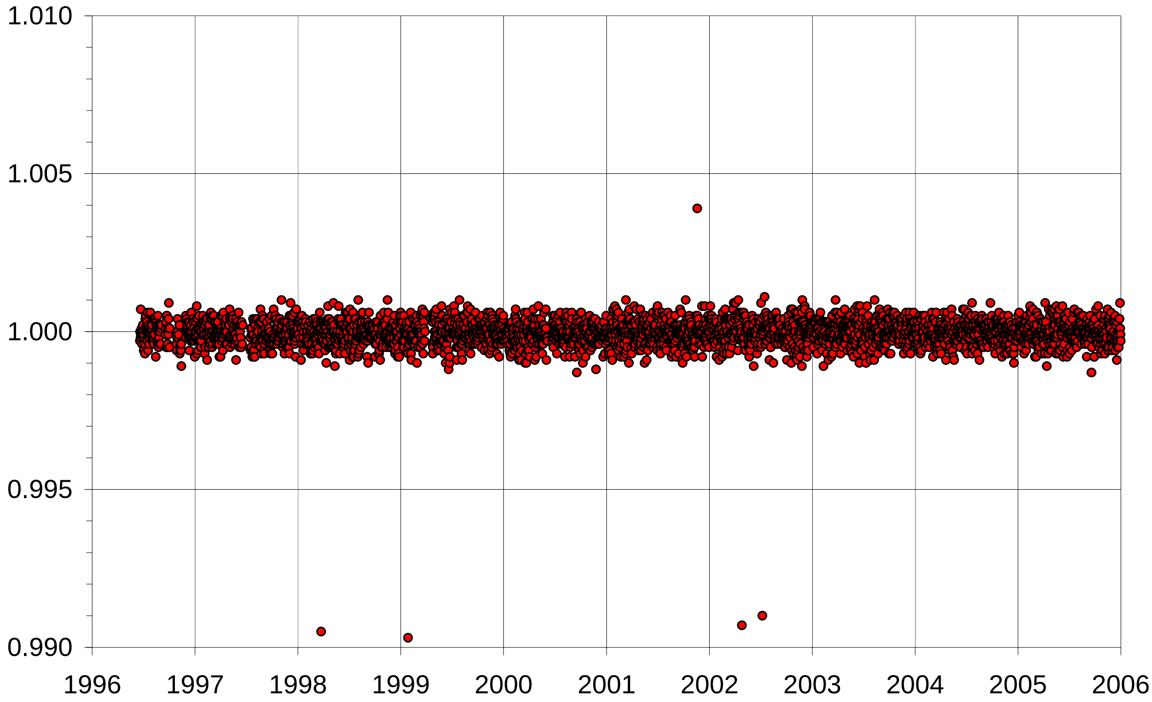

Figure 4.3. Run and stop test for Brewer #128 for the double slit position of the shutter mask for the period 1996-2005.

4.2 Brewer #006

As for the Brewer #128 the Brewer #006 status is tracked by doing the same type of tests on a daily schedule. At longer time intervals comparisons and service is done. Data on the results of these can be found in Appendix D.

The change in the responsivity of the Brewer #006 instrument is tracked using the standard lamp tests, Figure 4.4.

The observed differences in the SL-test R6-values can be added as a correction term to the calculated total ozone, TOZ_{ucor}, as

$$TOZ_{cor} = TOZ_{ucor} + (R6_{ref} - R6) / (\mu*10*\alpha),$$

where

$$TOZ_{ucor} = (R6 - ETC) / (10 * \alpha * \mu)$$

R6 is the measured weighted ratio of the radiances between the four wavelengths, ETC is the instrument constant, sometimes called the extraterrestrial constant, and α is the differential absorption coefficient, and μ is the relative optical path-length through the ozone layer. It can be seen that the correction term is μ-dependent meaning that the applied corrections will mostly be smaller in the winter, with a low sun, compared to the summer, with a high sun.

Mostly, Brewer #006 has shown only small changes in standard lamp tests results. However, as can be seen in Figure 4.4 there are exceptions. In 2002 a set of other absorption coefficients and a wavelength setting error caused a shift in the R6-values. A larger scatter in data can be seen mostly in 2003. This was first thought to be a consequence of a new electronic board. But, it remained after switching back to the old one. A visit to Vindeln in November 2003 revealed the reason. A bad contact had halted one of the filter wheels in a fixed position and the ground quartz plate was not used. This of course affected the standard lamp test. When the contact was re-established the standard lamp test results went back to their old values. However, the next day the lamp broke and had to be replaced. A new lamp will mostly give a slight shift in the test values. There will also be a time when the lamp burn in giving rise to a slight drift in the results.

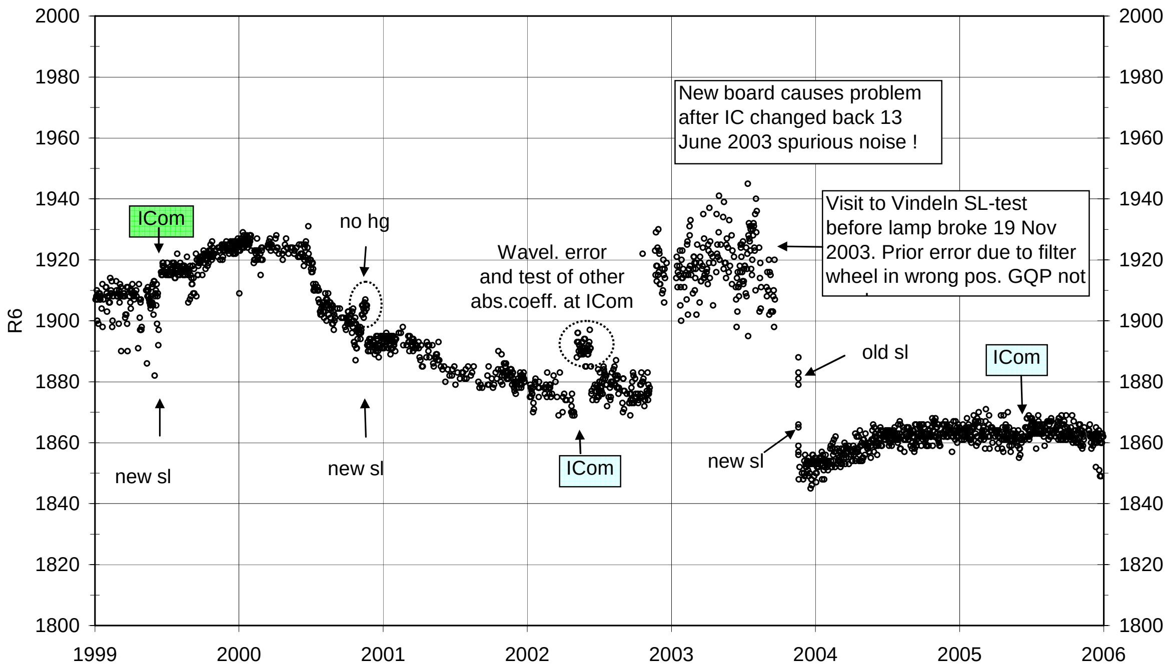

Figure 4.4. Standard lamp test value R6 for Brewer #006 over the period 1999-2005. Intercomparisons lamp changes are noted as well as comments to some outliers.

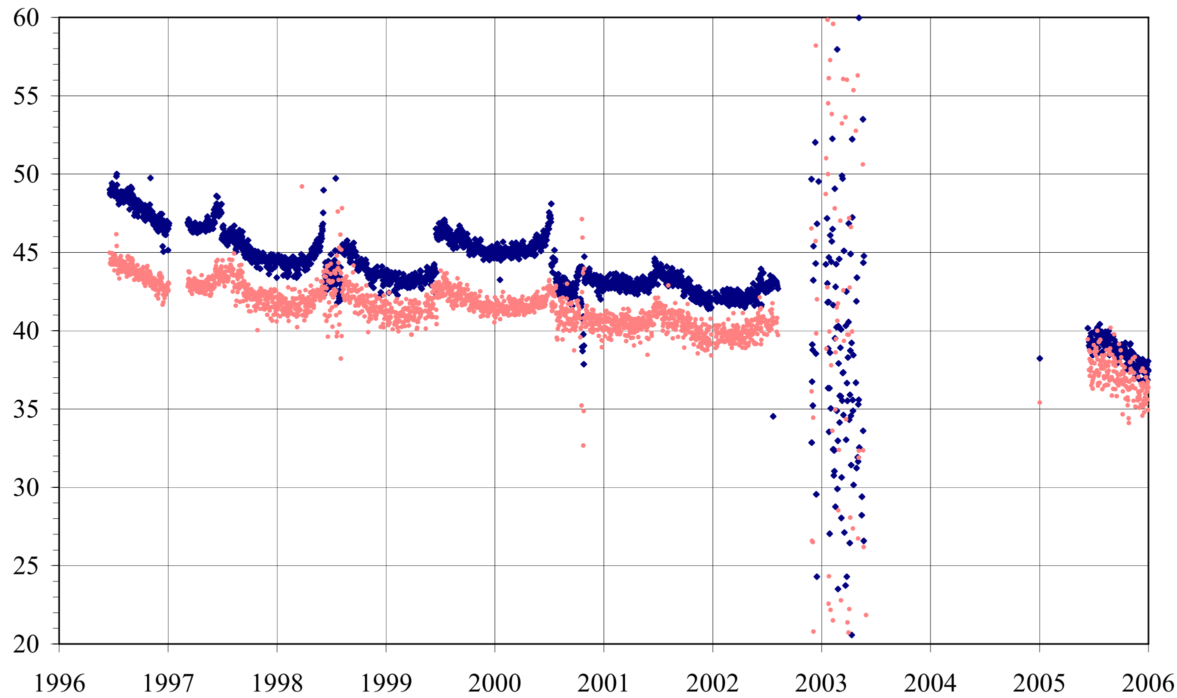

Figure 4.5. Dead-time for Brewer#006.

The dead-time of the Brewer #006 has decreased over the period 1996 to 2005, Figure 4.5. There has also been a clear yearly cycle. This is probably due to some temperature dependence. The filter wheel problems in 2003 also affected the dead-time tests which gave the large scatter seen in Figure 4.5. When the filter position error was corrected the dead-time test was not restarted. This was not noticed until the intercomparison in 2005. A new lower value of the dead-time was applied after the intercomparison.

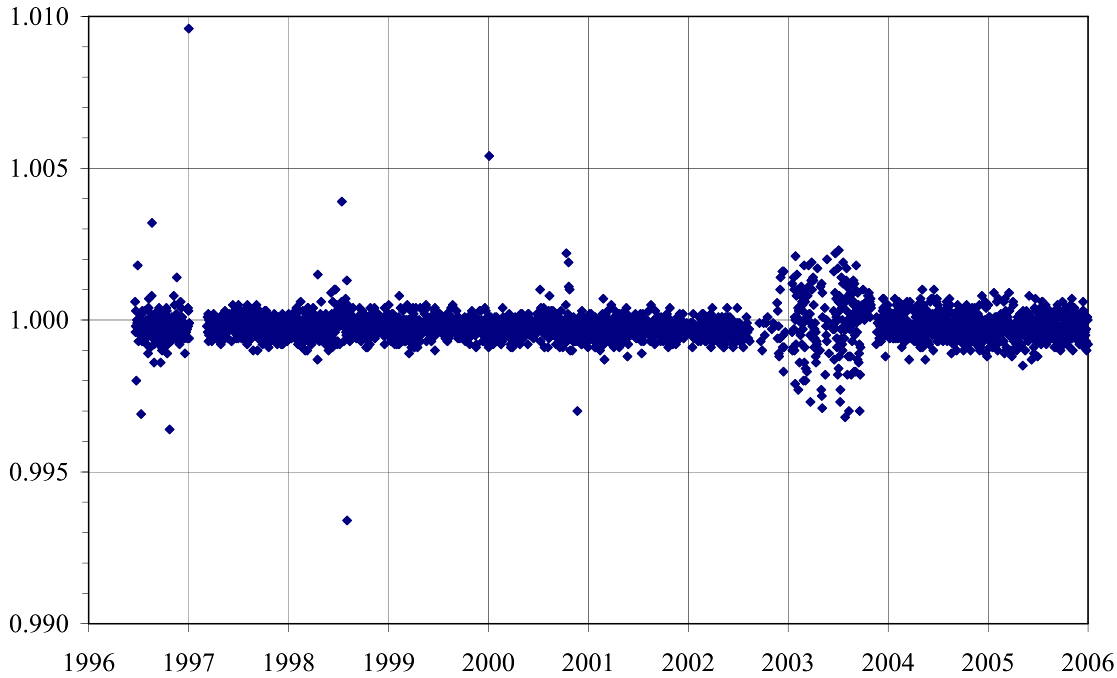

Figure 4.6. Run and stop test for Brewer #006 for the double slit position of the shutter mask for the period 1996-2005. Note the problems in 2003.

The run and stop test of Brewer #006 for the double slit position is shown in Figure 4.6. The result is very good with the exception of the period late 2002 and most of 2003 when a filter was stuck in an erroneous position. This caused a larger scatter in the data.

4.3 Dobson #30

The Dobson #30 was calibrated in June 2001 at Hohenpeissenberg, Germany. The results were encouraging. Initially there was a small difference versus the reference instrument Dobson #64. However, after cleaning the optics the following calibration showed very good agreement with the previous calibration at Arosa in 1996. It is now time to start planning for a comparison of the instrument in 2007.

It is worth noting that the parallel measurements of Brewer and Dobson at Vindeln have been used by Staehelin et al (2003). Data are delivered to WOUDC. Lamp calibrations are made once a month. The lamp 30Q1 is used every month, the lamp 30Q2 twice a year and the others once a year. Luckily, nothing spectacular has happened as can be seen in Figure 4.7. A slow change can be seen for the standard wavelength pairs A and D. However, the more sensitive wavelength pair C’ shows a clear change.

There is probably also a small temperature effect that is revealed in the yearly course. Although the instrument is kept inside a small hut there might be slightly lower temperatures in mid winter.

In 2006 the length of the Dobson series at Vindeln will be 15 years. By then it will also pass the length of the Uppsala series.

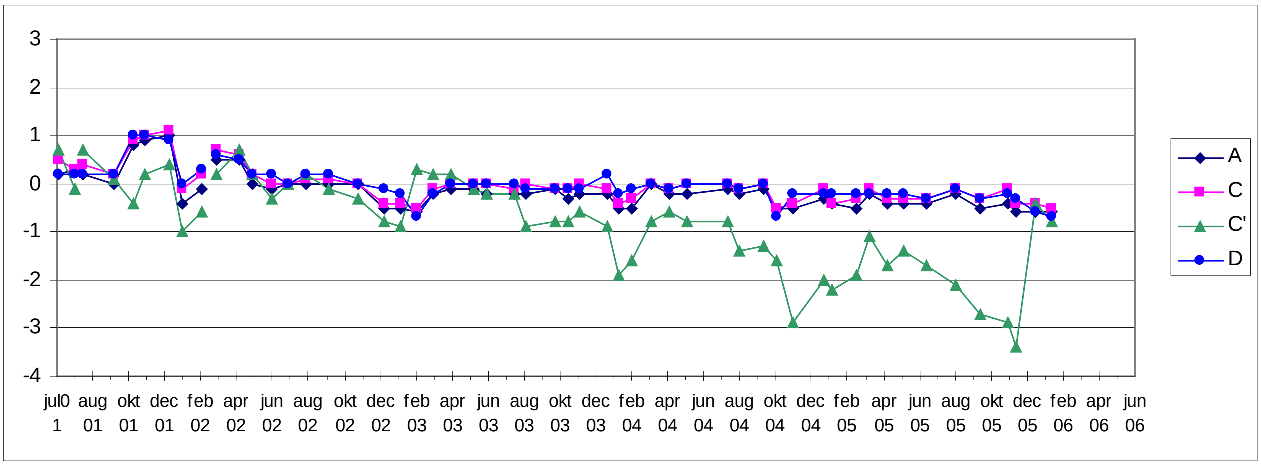

Figure 4.7. Results of the Dobson standard lamp tests for the period July 2001- December 2005. The various lines denoted by letters A, C, C' and D refer to the used wavelength pairs.

5. Observations

Over the period 2003-2005 the total ozone has varied a lot. In this section the daily data are plotted as one graph per year and site, Figures 5.1-5.6. The individual daily data are also given in Tables of Appendix C. Monthly mean values of the total ozone are listed in Appendix B. In these tables all monthly mean values since 1988 and 1991 are included for Norrköping and Vindeln respectively.

The nowadays typical deficit during spring-time is clearly seen for the years 2003 and 2005. The yearly course of the year 2004 is more closely positioned around the long-term mean. In spring of 2005 we had a very prolonged and cold polar vortex over the Arctic resulting in large deficits, -(15-20)%, of total ozone in February and March.

In a special UV-project the total ozone series was extended back to 1983 using TOMS-data (TOMS web-site). Linear trends were fitted to the individual months and their significances were tested at the 95% level. The result can be found in Table 5.1. Most monthly trends are negative and so was the trend for the year (-0.12% per year). But, the trends are usually very small and they are not significant. Only for one month the trend was significant, namely for September, with -0.28% per year.

The small trend in the last decades is also confirmed in Figure 5.7, where the long-term variation of the total ozone can be seen. It is a composite of Uppsala, Riga and Norrköping. To fill some gaps TOMS-data have been used. In general the ozone layer has been slightly thinner in later decades compared to earlier observations. An interesting feature is that there is an effect on the total ozone from the quasi bi-annual oscillation (QBO).

Table 5.1 Linear trends (%/year) for each month and for the year of total ozone at Norrköping 1983-2005. The observations starting in 1988 has been extended backwards to 1983 using TOMS-data . Tested for 95% significance.

Month	Trend (% per year)	Significance @95%
January	-0.24	0.56
February	+0.01	0.52
March	-0.21	0.48
April	-0.16	0.36
May	-0.12	0.27
June	-0.06	0.27
July	-0.05	0.18
August	-0.08	0.25
September	**-0.28**	0.21
October	-0.04	0.28
November	+0.02	0.22
December	-0.22	0.43
Year	-0.12	0.19

Figure 5.1 Daily 'noon' values of total ozone (red) recorded by Brewer #128 at Norrköping in 2003. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple).

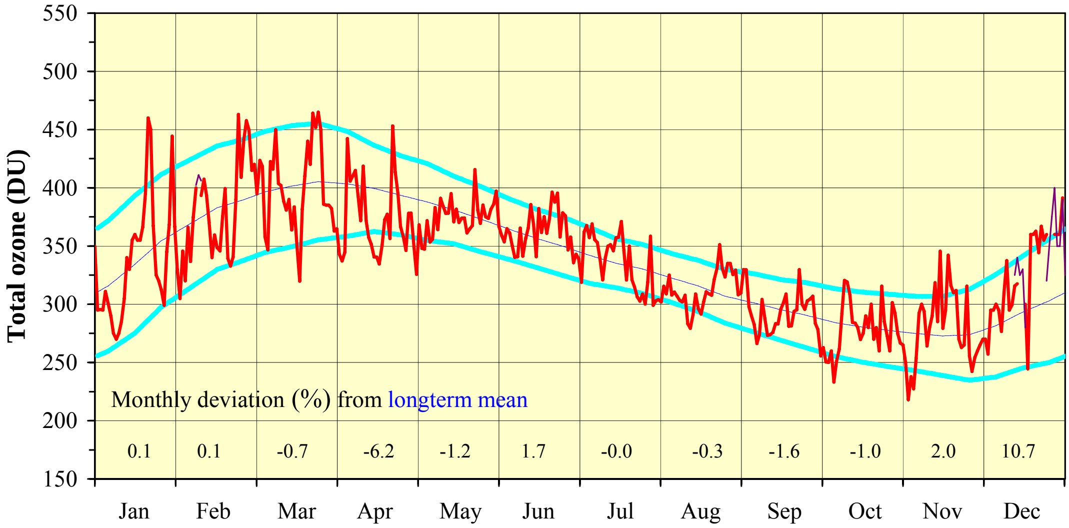

Figure 5.2 Daily 'noon' values of total ozone (red) recorded by Brewer #128 at Norrköping in 2004. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple).

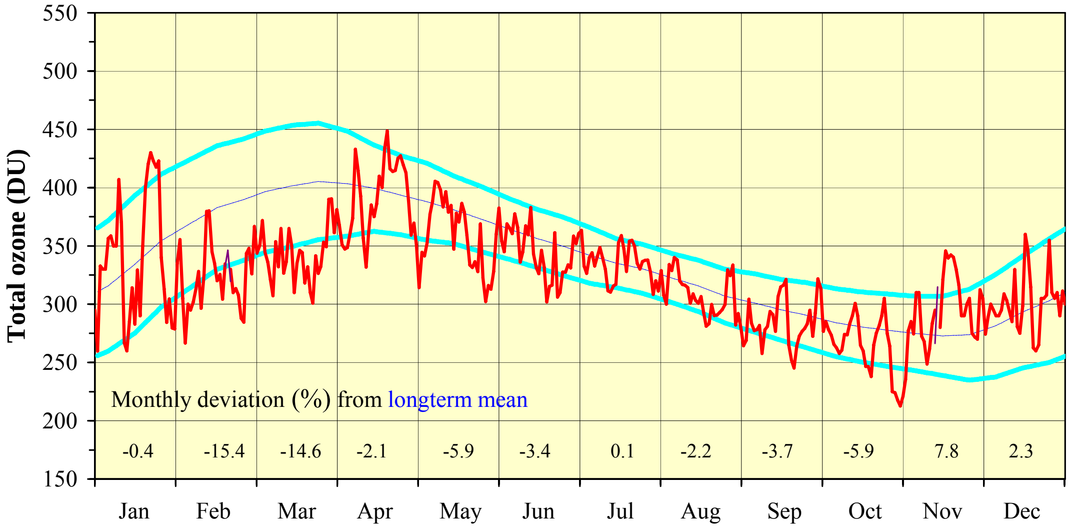

Figure 5.3 Daily 'noon' values (red) of total ozone recorded by Brewer #128 at Norrköping in 2005. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple).

Figure 5.4 Daily 'noon' values of total ozone recorded by Brewer #006 (red) and by Dobson #30 (green) at Vindeln in 2003. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to bass-Paur scale. Missing data are replaced by satellite data (purple line).

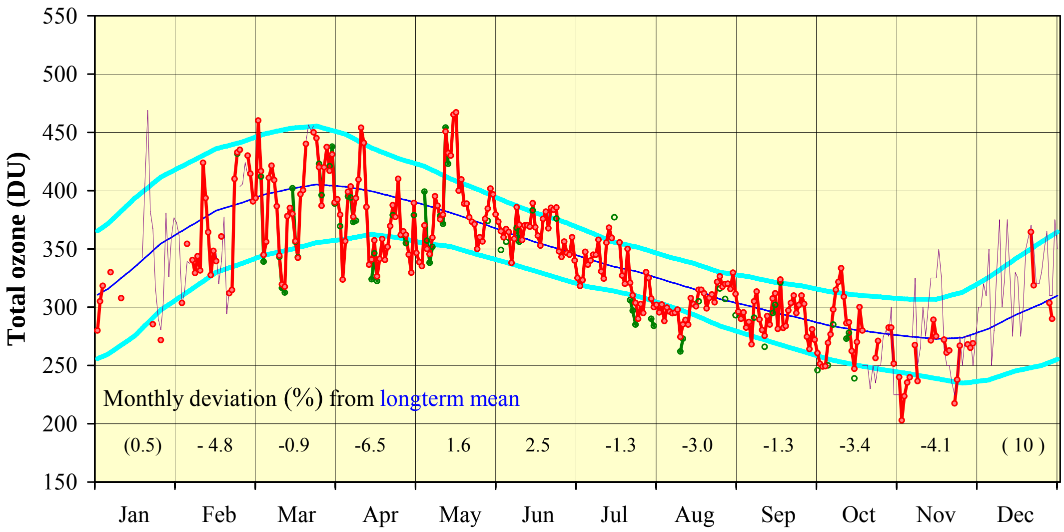

Figure 5.5 Daily 'noon' values of total ozone recorded by Brewer #006 (red) and by Dobson #30 (green) at Vindeln in 2004. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple line).

Figure 5.6 Daily 'noon' values of total ozone recorded by Brewer #006 (red) and by Dobson #30 (green) at Vindeln in 2005. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple line).

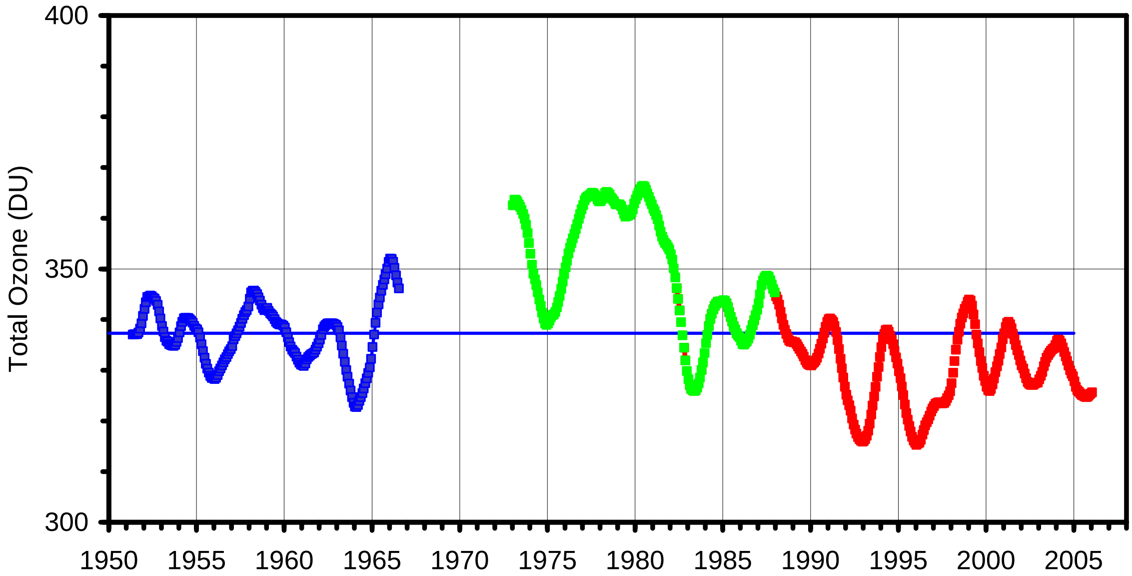

Figure 5.7 The long-term variations of the total ozone in Uppsala 1951-1966 (blue), Riga+TOMS 1974-1987 (green) and Norrköping 1988-2005 (red). The smoothed lines are based on monthly mean values that have been filtered by a two-year triangular filter. The blue horizontal line is the average from Uppsala.

6. Conclusions

Most of the months and also the yearly values of total ozone shows a negative trend over the period 1983 to 2005 over Norrköping. However, it is not significant when tested at the level of 95%. Therefore, during the last decades the total ozone over Sweden is neither decreasing nor increasing significantly. The natural variation is very large and therefore we must wait to observe, with significance, the expected recovery.

Despite some problems the monitoring delivers data. These data are stored and they are available at "Datavärden" www.smhi.se and at the WOUDC (World Ozone and Ultraviolet Data Centre).

7. References

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TOMS, The author gratefully acknowledge the NASA/GSFC's Ozone Processing Team in providing the TOMS total ozone data over their web site http://toms.gsfc.nasa.gov/

Appendix A

Events that affected the monitoring during the period

At the following dates, the Brewer #128 in Norrköping has had problems affecting the monitoring. After the hyphen the eventual measure taken is given. The list may not be complete but it gives an idea of typical problems and their frequency.

2003-01-08 Azimuth zeroing failure – restart
2003-01-30 Azimuth zeroing failure – restart
2003-04-27--29 Brewer indoors for UV-calibration
2003-04-30 Azimuth zeroing failure – big wheel cleaned
2003-04 and 05 Azimuth zeroing failure reappears – restart
2003-05-08 Moved diode fork for azimuth zero position, new siting values
2003-06-05—07 Visit from IOS for ozone calibration and service, tried new program, slight change in standard lamp test values. New extraterrestrial constants and temperature correction.
2003-07-01--04 stop no data -restart

2004-02-09 PC-power supply crash. Used spare Notebook for running the observations waiting for the power supply to be replaced.
2004-05-18 Monitoring stopped. PC-problem. Operated using the Notebook while replacing the old PC with a slightly more modern. Changed from Win3.11 to WinNT. Changed cable between PC and Brewer.
2004-09-21--22 Brewer in for UV abs. calibration
2004-11-20 Power break caused stop – restart next day
2004-12-13—15 Brewer indoors for temperature dependence test
2004-12-23—26 RCD (residual-current device) interrupted monitoring - restart
2004-12-30--31 unknown stop of program – restart

2005-01-18--20 RCD (residual-current device, jordfelsbrytare (Swedish)) interrupted monitoring - restart
2005-02-19 RCD (residual-current device) interrupted monitoring – restart
2005-04-07 RCD (residual-current device) interrupted monitoring - restart
2005-04-15--15 RCD (residual-current device) interrupted monitoring – restart
2005-06-22 Power break, PC didn't restart it was off?
2005-07-04 Power break, PC didn't restart it was off, manual restart after two hours
2005-10-21 interrupted monitoring, neutral density filter wheel didn't move, Brewer indoors, desiccant exchange and cleaning, checked contacts for oxidation, new grease on box-gasket everything OK- out and restart
2005-10-28—31 erroneous dates probably due to focused moon measurements – corrected in the morning
2005-11-10 Mercury lamp didn't work stopped monitoring. Brewer indoors, everything OK- out and restart.
2005-11-13—14 Program stopped after problems with the mercury lamp scans. Restart and it seems that the lamp is unstable.
2005-11-19—22 (weekend) Mercury lamp didn't work stopped monitoring. Brewer indoors, everything OK- Changed the HG-lamp despite this, Brewer out and restart.
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At the following occasions, dates, the Brewer #006 in Vindeln have had problems affecting the monitoring. After the hyphen the eventual measure taken is given. The list may not be complete but it gives an idea of typical problems and their frequency.

2003-04-18—23 tracker problem
2003-05-09—11 program stop may be bad connection
2003-05-30—06-01 testing new card without success gives nonsense data
2003-06-08--12 COM problem between Brewer and PC
2003-06-13 filter wheel
2003-07-03--07 COM err causes date error
2003-07-08 corrected dates
2003-07-22 azimuth problems
2003-08-10 extremely high counts both for zs and hg
2003-08-17 problem HG-high counts
2003-08-19 more problems could be GQP out, only zs available.
2003-08-21--25 ground quartz plate out- partly corrected from standard lamp test values
2003-09-11 Mikaell O-L pulled the electronic cards out and in to remove eventual corrosion = bad contact.
2003-09-11 COM err at midnight caused wrong date- corrected next day

2003-09-21 stop after midnight- restart next day
2003-09-23 power failure in large parts of Sweden
2003-09-26 unknown problem starts. No good observation
2003-11-19 Instrument box opened standard lamp exchanged

2004-02-04 Run and Stop test gave suspicious values.
2004-02-05 stop during day – restart
2004-03-21—22 stop – manual restart
2004-04-26 stop- automatic restart
2004-07-15—17 stop manual restart
2004-09-24 COM err (communication error) – manual restart
2004-11-02 COM err – manual restart
2004-11-30 COM err – automatic restart
2004-12-09 COM err – automatic restart
2004-12-17 COM err – automatic restart

2005-01-01 COM err – manual restart
2005-01-11 COM err – manual restart
2005-01-12 COM err – automatic restart
2005-01-14 COM err – automatic restart
2005-01-17 COM err – automatic restart
2005-01-18 COM err – automatic restart
2005-03-13 stop causes erroneous date – corrected same day
2005-03-18 COM err – automatic restart
2005-05-16 stop at midnight – manual restart at 11 15 UTC
2005-06-09 stop at midnight – manual restart at 11 25 UTC
2005-06-11--14 IOS calibration, change dead time setting, standard lamp position changed by shortening of pins, desiccant exchange in all containers, testing WinXP as new operative system on another PC and Internet connection. Problems occurred possibly due to virus attack?
2005-06-14 back to old PC
2005-08-25--29 COM err stop miss data – manual restart
2005-09-12 COM err – automatic restart
2005-10-06 COM err – automatic restart
2005-10-10 COM err – manual restart at 1057 UTC
2005-10-19 stop due to focused moon measurements – restart during day
2005-10-20 COM err – manual restart at 0605 UTC

Appendix B.

Monthly values of total ozone (DU) for the whole period at Vindeln (1991-2005) and at Norrköping (1988-2005).

Table B1. *Vindeln monthly values of total ozone (DU). Uncertain values (italic) are largely based on satellite observations. The highest monthly value is red and the lowest is blue for each month. The lack of data during the winter is mainly due to low solar elevation and the corresponding weak UV-radiance.*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1991		*360.3*	366.7	403.5	398.3	**373.1**	330.3	315.8	305.3	*281.1*	*273.5*	
1992		*316.2*	355.1	**409.0**	348.3	330.4	328.6	307.7	279.4	277.1	*274.9*	
1993	*323.6*	***287.0***	339.3	331.7	**334.5**	348.0	308.3	303.2	273.7	***256.1***		
1994		370.3	347.4	400.6	379.5	356.8	**308.2**	300.2	**310.8**	*267.5*		
1995			*347.2*	375.2	354.2	**319.1**	*325.2*	***278.0***	280.4	*257.1*		
1996			337.3	***330.8***	361.1	336.4	329.7	291.9	**271.3**	264.8	*278.6*	
1997		*347.8*	381.7	355.2	378.4	338.3	317.8	288.6	284.7	287.5	*269.2*	
1998		*339.2*	394.3	407.7	**395.5**	343.6	**347.7**	**339.0**	290.0	**289.7**	*277.4*	
1999		*382.8*	**430.0**	386.5	390.4	329.8	326.8	317.0	279.7	289.1	*268.0*	
2000	*308.0*	348.5	348.4	353.7	348.0	347.3	315.1	305.7	275.4	278.6	***253.8***	
2001	*315.9*	384.9	421.3	400.8	372.8	352.9	314.1	306.8	283.4	283.3	***285.6***	
2002	***307.2***	**399.0**	397.9	371.8	339.0	337.9	315.9	293.3	275.3	**289.7**	*265.9*	
2003	*320.8*	*317.6*	**335.4**	391.2	380.7	359.5	316.0	310.9	281.7	271.9	*285.0*	
2004	***338.2***	*362.3*	397.7	372.2	385.2	364.7	330.1	304.4	290.9	271.0	*263.2*	
2005	*322.0*	297.6	337.9	403.9	372.0	342.5	320.3	295.6	287.6	262.0	*282.6*	

Table B2. *Norrköping monthly values of total ozone (DU). Italic values are largely based on satellite observations and may be uncertain. The highest monthly values are bold and red and the lowest ones are bold and blue for each month.*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1988	*333.6*	380.7	**418.5**	393.3	366.7	343.0	336.3	319.5	286.5	275.0	283.3	326.1	338.4
1989	*306.6*	394.5	391.4	383.7	371.1	347.7	335.9	322.5	287.7	278.7	280.1	*314.0*	334.1
1990	*322.8*	346.4	383.5	381.8	355.7	343.6	331.1	312.9	295.8	280.9	**302.5**	*310.5*	330.5
1991	361.6	383.1	376.1	400.2	**393.2**	**377.2**	332.8	321.4	298.9	286.2	286.4	287.9	**341.8**
1992	**265.8**	343.8	365.8	392.2	352.3	336.8	326.9	300.3	**279.8**	293.0	284.4	295.7	319.5
1993	316.7	**296.6**	342.8	**335.1**	**340.3**	340.9	326.1	315.7	284.0	*286.9*	*297.9*	*302.0*	**315.6**
1994	***363.6***	388.1	369.2	397.9	376.2	358.5	**322.2**	320.4	**320.0**	284.1	283.0	*315.7*	341.2
1995	310.5	370.2	370.0	378.0	360.4	**323.1**	323.7	**295.8**	288.8	270.5	271.9	297.0	321.3
1996	287.9	341.6	**332.5**	337.7	363.8	346.2	341.4	300.7	284.3	270.3	279.4	302.6	315.6
1997	318.2	369.0	365.5	361.7	367.7	345.8	333.1	296.4	281.0	290.7	276.7	**250.1**	321.0
1998	311.4	341.3	383.1	391.1	383.6	349.7	**361.0**	**341.6**	292.2	**303.2**	287.0	329.5	339.6
1999	352.7	**394.8**	414.9	*379.5*	376.7	335.3	330.5	320.4	280.5	296.0	276.2	325.4	340.0
2000	312.1	353.1	344.2	355.1	350.3	343.1	335.5	312.2	282.6	282.6	**269.1**	***333.4***	322.7
2001	340.7	389.9	417.6	**405.7**	374.4	365.4	326.0	310.6	295.2	280.2	282.0	297.8	340.1
2002	304.1	376.7	391.4	386.6	342.5	348.3	325.8	305.8	281.4	300.6	286.5	265.2	325.8
2003	334.9	344.0	345.2	402.3	381.6	362.5	334.0	319.5	293.4	289.9	281.8	292.9	331.7
2004	336.8	381.0	398.7	373.3	374.6	362.0	334.6	312.8	290.0	277.5	279.7	326.4	337.2
2005	337.8	321.7	342.3	390.2	357.4	344.3	335.6	307.5	284.3	**264.0**	295.7	300.5	323.4

Appendix C.

Table C1. *Daily values of total ozone (DU), Vindeln 2003 Brewer # 006*

2003	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1			285.0	415.0	398.9		331.6	314.3	318.5			
2			285.0	435.0	418.5	344.7	328.6	290.0	312.7			
3			290.0	435.9	424.6	329.0	321.5	317.6	275.0			
4			310.0	405.0	434.6	344.2	325.4	318.5	301.7			
5			300.0	465.4	390.0		330.0	344.2	274.9			
6		322.3	300.0	444.8	400.0	355.0	324.2	316.2	272.4			
7		272.2	330.5	379.3	429.1	361.6	331.1	295.0	280.9			293.0
8			300.8	382.1	389.0	374.1	319.4	318.1	281.5			300.0
9			360.0	353.3			330.7	306.5	288.1			275.0
10			310.0	373.2			351.9		274.4			
11			371.8	437.5			321.8	293.7	274.6			
12		298.2	392.8	390.2	384.4		321.0	300.0	276.4			335.0
13			310.5	406.7	378.5	362.0	313.1	315.0	252.1			
14		363.2	299.7	354.1	370.0	408.2	290.0	315.0	240.9			
15		324.1	325.6	383.3	399.4	385.1	304.1	330.0	276.0			
16		351.0	298.4	378.3	364.1	389.6	306.7	301.7	279.5	242.1		
17		329.5	278.2	346.8	353.4	395.2	309.8	296.8	271.3			
18		315.2	295.0		353.4	369.7	301.9	293.8	253.1			
19		288.2	332.9		365.0	375.0	302.2		290.4	278.1		
20		298.4	318.1		348.1	368.1	311.7	315.0	295.0			
21		339.5	281.8		359.6	378.7	310.0	335.0		283.4		
22		357.8	273.5		367.7	372.5	314.1	330.0		263.6		
23		343.3	330.0		372.8	377.6	317.4	310.0		264.1		
24		341.6	377.2	395.0	372.5	349.1	307.5	320.0	299.7	280.6		
25		328.8	380.3	412.3	343.0	344.0	317.7	300.0				
26		301.1	354.1	393.9	323.5	362.4	321.4	320.0				
27		301.8	366.1	401.1	354.6	343.4	314.5	300.0				
28		283.9	417.9	396.4	401.4	348.8	301.7	305.0				
29			390.0		352.9	330.0	303.5	308.9				
30	345.9		470.0	392.0		326.9	307.7	310.0				
31	329.0		463.1				302.8	322.6				

Table C2. *Daily values of total ozone (DU), Vindeln 2004 Brewer # 006*

2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	280.0		393.7	392.4	346.5	373.3	325.0	295.4	290.0	251.4	202.9	
2	305.0	303.7	460.0	379.2	338.7	365.1	318.2	302.3	295.5	249.1	223.5	
3	318.3		416.7	323.7	335.3	360.0	323.2	288.1	282.4	249.4	235.3	
4		354.3	344.8	356.5	370.0	367.0	347.3	299.6	287.3	269.4	239.8	
5			356.1	398.9	350.0	364.4	336.4	296.2	268.2	276.7		
6	330.0	340.4	410.9	403.5	345.4	337.9	340.0	294.8	305.0	298.1	267.5	
7		329.3	421.2	377.6	359.7	358.6	345.0	295.2	313.3	315.0	236.5	
8		343.8	408.9	393.5	395.1	385.8	345.0	297.8	289.5	321.5		
9		331.4	386.6	409.3	387.0	370.6	357.7	274.4	280.4	333.4		
10	307.7	423.8	344.3	453.9	375.3	357.6	330.6	285.2	275.4	308.9		
11		393.7	319.5	440.9	379.3	370.0	324.4	289.0	292.4	286.3		
12		364.3	317.4	386.0	450.6	370.3	355.2	285.1	285.0	287.0	271.4	
13		327.6	378.1	336.5	432.2	369.0	368.1	307.7	307.4	262.4	289.1	
14		348.2	385.0	340.9	430.0	389.1	359.3	302.7	311.9	247.2	274.9	
15		339.5	380.0	357.3	465.1	368.6		300.8	281.2	270.0		
16			356.6	326.3	467.0	361.4		314.9	323.6	300.0		
17		360.6	342.4	341.3	400.0	352.8	355.5	315.0	282.1	280.0	272.0	
18			396.8	358.4	409.5	375.7	327.1	311.8	283.9		260.9	
19			400.2	340.5	388.8	381.8	320.0	298.9	297.2		262.9	
20		312.0	440.0	351.6	388.8	367.7	350.0	307.9	303.7			364.4
21		314.7		369.6	377.1	385.2	320.9	310.9	310.0		217.5	318.7
22	285.4	410.0		387.4	373.3	383.5	310.1	304.2	294.9	256.3	237.8	
23		432.7	450.0	377.4	371.3	385.5	303.7	321.5	301.7	271.0	267.0	
24		435.0	445.0	410.0	350.0	347.9	290.0	326.4	310.0			
25	271.8		420.0	362.1	360.0	343.1	302.6	317.4	302.8			
26			387.0	365.0	356.4	356.3	294.9	319.9	274.6		268.0	
27		430.0	419.9	362.1	375.7	346.3	330.0	320.0	264.0	282.4	265.0	303.6
28		414.4	437.3	345.2	384.6	345.0	325.0	315.6	281.0	282.5	269.0	290.0
29		390.8	417.0	329.6	401.7	360.0	307.3	329.6	272.0	251.5		
30			431.0	389.4	396.7	340.0	300.1	311.3	260.7			
31			389.8		379.6		302.0	296.1		240.0		312.0

Table C3. *Daily values of total ozone (DU), Vindeln 2005 Brewer # 006.*

2005	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1			323.1	371.9	395.4	370.1	342.8	303.1	266.6	263.4		
2			319.1	345.3	368.3	376.4	355.1	327.1	264.5	270.0		
3			322.1	338.7	360.0	381.7	335.5	299.9	294.9	275.9		
4			310.0	358.2	355.0	360.6	322.3	300.5	285.7	281.4		
5			335.0	400.0	361.9	355.0	323.1	329.6	277.4	255.4		
6		312.5	304.3	383.1	380.3	359.8	320.3	323.1	278.6	261.1		
7			322.8	395.0	385.6	385.7	328.4	350.0	280.0	258.4		
8		276.6	319.3	415.0	375.0	375.7	334.3	295.1	289.4	259.3	272.7	
9			306.1	419.6	380.8	336.4	347.0	282.2	323.2	290.0	253.9	
10			318.0	408.9	387.5	340.4	317.5	285.3	301.6	280.2	272.7	
11		339.7	342.5	417.2	367.3	351.2	308.4	310.0	279.9	283.6	279.6	
12		323.8	323.7	390.0	375.1	344.2	280.2	296.0	301.0	286.8		
13			342.2	417.8	394.5	298.9	305.2	297.0	287.0	315.0	300.8	
14			334.5	410.3	365.3	310.7	292.1	291.7	275.0	315.0		275.0
15		251.6	338.7	418.1	395.4	326.3	319.1	295.1	307.9	279.0	300.0	
16		282.3	343.7	413.3	350.0	317.6	322.7	300.0	330.5	249.5	307.1	
17			335.0	401.3	410.0	323.8	313.8	301.5	314.1	235.0	334.2	
18			365.0	435.5	379.0	331.5	321.4	271.6	274.4	236.6	325.4	307.0
19			358.7	433.8	393.2	327.4	320.0	271.6	244.2	249.6		
20		300.0	359.3	425.0	380.1	316.2	311.6	282.5	250.6	235.9		
21		298.4	353.9	438.2	345.6	312.3	327.8	278.9	293.3	258.8		
22		282.2	310.9	408.9	349.1	355.0	298.4	265.0	290.6	279.6		
23	387.0	272.1	315.0	406.1	339.1	334.8	311.5	283.6	274.4	297.6		
24	370.0	260.8	321.0	411.0	341.1	324.5	325.6	290.9	277.1	269.6		
25		320.0	334.4	413.6	364.1	355.5	321.6	290.0	286.5	244.7		
26		314.5	336.0	414.6	355.3	342.4	313.9		294.6	270.0		
27		311.1	350.0	414.2	387.2	337.3	325.8		260.2	240.2		
28	255.4	307.8	400.0	415.9	384.3	356.7	324.1		276.3			
29	243.7		388.8	410.7	367.5	352.8	337.5	286.7	319.8			
30			371.9	384.5	373.7	350.9	319.1	310.2	328.9			
31	384.4		368.6		363.8		302.2	280.1				

Table C4. *Daily values of total ozone (DU), Norrköping 2003 Brewer # 128.*

2003	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	300.0	370.6	310.0	425.6	433.3	361.5		308.3	341.4	305.0	335.0	265.0
2	300.0	400.0	325.0	445.0	414.4	345.1		333.8	323.6	312.5	335.0	265.0
3	310.2	415.0	335.0	459.4	430.0	341.8		304.8	303.3	257.2	327.9	270.0
4	315.4	370.0	341.2	401.5	399.9	347.7	384.3	322.1	307.5	280.0	344.3	265.0
5	298.0	340.0	324.6	474.3	368.6	332.8	357.5	324.6	296.6	302.9	283.7	280.0
6	292.2	331.3	329.1	471.9	408.5	355.2	347.5	316.7	300.2	279.1	266.2	344.6
7	296.8	287.2	376.9	423.3	419.0	340.6	341.6	312.4	315.5	300.0	240.0	249.8
8	301.1	270.1	315.0	442.9	367.7	326.8	344.9	315.0	324.3	276.1	260.0	254.4
9	286.3	288.8	361.4	435.0	366.1	400.6	351.7	303.6	317.4	286.1	260.0	260.0
10	293.4	320.0	369.3	430.0	384.9	350.8	346.2	299.5	315.3	293.2	270.0	294.9
11	260.0	290.0	400.3	445.0	387.6	377.7	327.8	302.6	297.0	285.4	275.0	282.0
12	255.5	300.0	390.0	447.3	394.1	341.0	353.3	319.0	286.3	279.1	290.0	291.1
13	264.8	355.0	363.4	393.5	373.2	378.8	321.4	299.9	286.2	289.8	305.0	290.0
14	308.9	383.1	318.4	363.0	378.5	383.4	326.4	356.9	248.6	303.2	300.0	310.0
15	270.0	394.9	341.3	362.9	425.5	362.8	322.0	348.7	275.1	298.8	290.0	359.3
16	327.5	367.9	304.3	368.6	427.2	402.5	325.3	339.2	296.6	291.2	310.0	266.1
17	295.0	352.3	289.0	369.4	417.0	356.7	330.5	320.5	273.6	280.5	295.0	246.2
18	348.7	346.7	278.2	365.2	397.7	372.7	316.1	307.0	268.5	269.0	290.0	305.0
19	330.0	309.8	293.9	350.8	396.5	385.8	321.6	340.0	258.5	260.8	276.6	305.0
20	375.0	326.3	319.8	353.4	366.8	379.6	342.6	319.7	285.4	293.9	265.5	308.8
21	325.0	368.7	301.0	371.4	394.3	369.9	320.9	302.2	294.0	296.2	270.0	325.0
22	335.0	400.0	275.2	369.9	378.5	381.9	322.2	300.0	273.3	294.8	285.0	361.2
23	340.0	370.0	289.7	373.9	354.4	349.4	327.3	334.0	289.9	326.4	260.0	323.5
24	449.1	355.0	366.5	370.4	337.4	372.3	330.1	318.8	290.5	289.6	250.0	290.0
25	400.0	330.0	380.1	400.3	325.9	349.4	336.6	316.1	275.1	284.0	260.0	285.0
26	430.0	305.0	348.1	376.4	329.4	362.2	329.2	316.6	275.8	316.6	260.0	286.0
27	400.0	345.0	365.6	400.0	337.9	362.1	320.1	331.5	300.2	264.9	265.0	285.0
28	420.0	340.0	391.5		350.8	362.2	309.3	325.7	280.0	254.9	270.0	290.0
29	370.0		416.9	380.0	335.7	357.7	317.7	320.0	300.8	305.1	260.0	285.0
30	456.6		426.3	387.1	361.6	362.7	317.6	316.9	301.3	305.0	255.0	287.7
31	426.7		452.8		365.7		304.8	328.7		305.0		349.5

Table C5. *Daily values of total ozone (DU), Norrköping 2004 Brewer # 128.*

2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	295.0	304.8	394.8	342.8	368.1	358.9	318.9	315.5	329.6	250.3	218.0	257.2
2	295.4	345.7	423.5	337.1	348.1	353.7	362.0	308.9	297.9	250.0	237.7	295.0
3	295.0	320.0	418.3	344.7	347.3	365.0	367.7	325.0	290.0	260.0	227.3	295.0
4	311.0	366.2	357.9	442.2	371.7	361.2	357.3	307.9	282.7	233.2	253.7	300.0
5	300.0	336.8	346.6	405.7	353.4	350.2	369.0	310.4	266.3	250.6	292.4	295.0
6	290.0	374.9	422.4	410.0	355.9	340.4	355.5	306.7	274.0	261.7	300.0	276.6
7	275.0	400.0	416.0	415.0	383.0	340.8	353.0	303.1	304.1	292.1	293.9	309.9
8	270.0		450.0	392.8	364.0	365.5	339.3	301.9	287.6	320.6	264.2	337.4
9	275.0	393.2	403.7	371.8	391.1	341.2	320.9	307.7	273.3	319.1	280.0	295.0
10	285.0	407.2	401.9	418.5	384.3	356.4	340.0	283.1	273.7	308.3	290.0	299.4
11	305.1	393.2	388.3	372.0	377.9	365.5	350.0	279.2	275.8	284.3	318.5	315.7
12	340.0	370.0	380.9	357.4	378.2	385.6	351.1	291.2	283.3	283.8	285.0	317.7
13	330.0	340.0	390.0	351.6	395.0	368.9	346.0	308.7	283.1	280.0	345.5	
14	355.0	359.4	363.8	340.5	370.7	340.8	357.1	296.2	295.6	269.6	279.2	
15	360.0	348.5	383.6	340.5	381.7	382.1	357.5	291.6	301.4	275.0	295.0	300.0
16	355.0	345.8	349.7	334.5	370.1	361.6	371.1	301.9	308.8	290.0	342.0	244.5
17	355.0	375.0	319.8	351.0	374.0	375.1	345.8	310.8	281.1	280.0	316.1	360.0
18	366.1	399.4	381.5	372.7	374.1	360.9	320.7	308.8	281.4	300.0	310.0	360.0
19	395.0	339.4	410.0	377.2	361.1	373.6	350.0	307.7	293.9	270.0	311.8	362.7
20	460.0	332.7	440.0	356.4	364.7	396.2	321.0	321.3	295.2	280.0	270.0	344.2
21	450.1	340.7	420.0	453.0	367.5	387.7	315.0	331.0	329.8	260.0	262.8	367.0
22	367.4	390.0	464.2	413.4	415.7	395.3	306.4	351.1	300.0	315.6	265.0	355.0
23	325.0	462.9	451.7	395.0	380.7	357.7	302.7	330.9	295.6	285.0	315.6	360.0
24	320.0	409.0	465.0	366.7	369.4	378.4	308.7	323.5	303.0	272.7	255.5	
25	312.3	441.6	450.0	358.1	385.2	375.8	300.2	335.0	304.3	260.0	242.4	
26	299.1	457.6	386.0	346.1	375.0	346.6	319.1	335.0	306.9	301.4	254.5	360.0
27	345.0	449.7	385.0	378.1	373.6	357.8	358.4	325.5	283.5	292.4	260.0	360.0
28	368.4	415.0	385.1	378.3	381.6	335.6	299.1	329.2	278.3	274.6	265.0	360.0
29	444.3	420.0	382.1	349.2	385.9	343.0	302.9	308.1	255.7	266.6	270.0	391.4
30	366.7		362.9	325.7	397.2	339.1	304.0	309.7	262.9	265.0	270.0	
31	330.0		364.8		366.6		301.9	329.7		250.0		295.0

Table C6. *Daily values of total ozone (DU), Norrköping 2005 Brewer # 128.*

2005	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	259.7	355.3	366.7	381.1	349.8	382.6	360.7	328.7	264.4	276.7	235.5	274.3
2	332.7	305.0	343.8	367.6	314.3	354.1	363.3	307.5	268.8	285.0	277.2	288.5
3	330.0	266.6	350.6	350.9	344.5	345.0	332.6	300.0	304.3	278.3	285.0	300.0
4	330.0	300.0	371.8	347.3	341.4	368.9	326.3	334.1	283.7	273.5	274.4	295.0
5	356.6	295.0	344.6	348.5	352.5	365.2	340.0	328.9	277.3	265.6	310.0	290.0
6	358.7	301.7	335.9	361.0	377.0	360.5	344.1	340.0	278.0	262.7	310.0	290.0
7	350.0	313.3	321.0	373.6	388.0	377.5	332.6	337.9	281.8	257.8	272.5	295.0
8	350.0	328.1	307.2	432.9	405.4	365.8	341.1	319.9	257.8	260.6	267.9	308.7
9	407.0	296.4	353.7	414.6	404.4	336.1	348.8	317.0	278.1	274.1	248.6	303.2
10	370.0	325.0	332.0	392.6	398.0	344.8	339.7	316.2	280.9	273.6	261.7	294.5
11	266.7	379.7	365.0	356.7	383.3	367.2	329.9	314.3	293.7	283.6	283.1	285.0
12	260.0	380.0	326.5	331.9	396.5	359.5	311.5	301.0	291.0	290.3	295.0	329.8
13	285.0	345.0	336.3	362.0	379.0	382.8	310.3	308.7	276.7	300.8		280.6
14	314.1	335.0	365.0	385.0	384.8	343.1	315.6	303.2	306.6	290.0	280.0	275.0
15	282.8	320.0	350.0	375.0	347.1	331.5	317.2	300.7	315.0	264.8	321.2	298.5
16	329.2	325.5	310.0	386.1	378.1	326.2	352.9	306.6	316.2	260.0	345.7	360.0
17	290.0	304.3	335.0	409.9	370.5	346.1	358.8	292.9	321.3	246.7	339.7	346.9
18	350.0	334.8	346.2	400.1	386.4	331.4	347.1	281.1	265.0	246.7	342.2	314.5
19	400.0		344.2	433.7	378.9	302.0	328.1	283.4	251.9	238.0	340.3	262.5
20	420.0	330.0	318.1	448.6	359.0	315.3	354.0	299.8	245.2	265.0	330.0	260.0
21	430.0	310.0	332.0	416.2	333.6	316.3	354.8	290.4	264.1	275.1	316.3	265.0
22	422.9	313.3	310.1	413.7	331.4	361.4	350.0	290.6	272.8	281.7	290.0	305.0
23	417.5	308.0	301.0	414.6	336.4	306.1	335.0	292.9	276.7	290.0	290.0	305.0
24	422.8	287.9	341.5	425.2	327.9	310.0	330.1	295.2	279.2	305.0	300.0	307.8
25	340.0	284.5	326.3	427.2	368.9	327.6	336.6	299.7	283.4	275.0	305.0	354.8
26	313.1	343.6	332.4	419.5	322.6	327.6	337.7	329.4	294.7	264.0	275.0	310.0
27	284.4	347.9	353.2	412.8	302.3	333.7	337.8	324.5	272.4	224.9	271.8	305.0
28	304.5	326.0	349.2	388.9	316.0	331.1	327.5	333.6	292.4	224.1	270.0	310.0
29	279.6		390.0	359.3	312.8	358.5	308.5	282.2	321.7	217.5	312.4	290.0
30	278.8		390.3	369.6	328.0	352.0	320.0	291.9	313.8	212.7	304.6	311.4
31	335.1		361.3		360.0		311.3	279.7		221.0		300.0

Table D1 History of intercomparisons, used instrumental constants and major changes of Brewer #006.

DATE	OZONE		SO_2		SL		REFERENCE Calibration site	Temperature coefficients					Remarks
	ETC	Abs	ETC	Abs	Ra 5	Ra 6							
1982 May	2832	.3583	2595	1.150	3520	1820	Br MkI #1 Toronto	4.8	5.14	4.77	3.71	3.07	
1983 Sep	3070	.3436	2935	1.1458	3710	1970	Br#008 Toronto	1.517	1.16	1.912	3.71	5.298	
		.3570		1.190									not used but in the result
1987 Oct	2792	.3409	2420	1.1354	3200	1685	Br#008 Toronto	-1.206	-0.6622	-0.9659	-1.630	-3.176	
					3165	1665							typical values Jan-May 1989
1989 Jun	2826	.3314	2582	1.11369	-	-	Br#017 Norrköping						#017 old temp coeff. used
	3031	.3409	2970	1.1354	-	-							SL temporary values used by K.Lamb probably from SL-test
													POLARIZ. PRISM REMOVED
	3045	.33483	3100	1.11876	3665	1895	Br#017 Norrköping	-1.206	-0.6295	-0.9765	-1.747	-3.043	
1991 Jul							Br#017 Norrköping						No change of current parameters
1992 Mar		.34412		1.14980									Change to Bass-Paur scale 0.973
1993 Nov	3034.098	.3509	3003.625	1.1712		1927	Br#017 Izaña						Note: New dispersion coeff. The change appeared at Izana
1995 Dec													The dispersion was changed back Izana disp. probably in error
1996 May	no change	no change					Br#017 Norrköping						Br#128 was calibrated, no change of Br#006 because close to Br#017 and Br#128
1997 Jan	OK	OK					Br#128 Norrköping						Power supply burned. Comp. vs Br#128 no change of ozone calibration
1999 June	no change	no change					Br#017 Vindeln						New SL, dispersion file change introduced DCF16999.006
2002 June	2995	,3509	2945	1,1702	3610	1875	Br#017 Vindeln						
2005 June	2995	.3509	2945	1.1702	3610	1875	Br#017 Vindeln						Dead time change from 44 to 40ns

Table D2 History of intercomparisons, used instrumental constants and major changes of Brewer #128.

DATE	OZONE		SO_2		SL		REFERENCE	Temperature coefficients					Remarks
	ETC	Abs	ETC	Abs	Ra 5	Ra 6							
1995 Dec							Br #017 Saskatoon						
1996 May	1829	0.3491	827	4.171	1290	590	Br#017 Norrköping	0	1.2642	2.0027	2.3022	2.5021	hg-cal step 287
1996 Oct	OK					590-> ->585	Br#017 NOGIC96 Izaña						
1997 Jul	OK					582	other Brewers at SUSPEN Thessaloniki						
1999 Jun	1795 1723	0.3491	760 644	1.171	1225 1107	550 484	Br#017 Vindeln Standard Lamp Norrköping decreased during the year						Sudden change after transport home change of constant based on change in SL-values
2000 Jun	1715	0.3491	635	1.171	1065	470	Br#017 Tylösand						Changed dispersion coeffi.
2003 Jun	1700	0.3491	600	1.171	1000	463	Br#017 Norrköping	0	0.1029	.0962	.3465	.2688	New temp coeff