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Front:
Sun glitter and morning mist in Stockholm archipelago.
Photo: Weine Josefsson.

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Summary

This report summarises the quality control, quality assurance and measurements of total ozone at Norrköping and Vindeln for the period 2012-2015. Significant incidents affecting the measurements are documented. Daily data are listed and plotted.

This work was supported by the Swedish Environmental Protection Agency.

Sammanfattning

Rapporten sammanfattar kvalitetskontrollen, kvalitetssäkringen och mätningarna av totalozon vid Norrköping och Vindeln under perioden 2012-2015. Händelser som signifikant påverkat mätningarna är dokumenterade.

Arbetet har finansierats av Naturvårdsverkets Miljöövervakning (programområdet Luft, delprogrammet ozonskiktets tjocklek) och denna period avser Avtal Nr. 211 1002 och 211-14-002 med ärendenummer NV-11173-11 och NV-08341-13. Motsvaras vid SMHI av följande diarienummer 2014/492/10.3 samt 2012/1108/10.3.

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1. Introduction

The purpose of this report is to summarize and document the ozone monitoring project for the period 2012-2015. 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, SLU, in Vindeln at 64.24°N 19.77°E 225m. Regular monitoring started for these two sites 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 MkIII. In Vindeln Brewer ozone spectrophotometer #6 Mk II is in use since 1996, and Dobson ozone spectrophotometer #30 since 1991. The latter is the same instrument that was used in Uppsala in the period 1951-1966.

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

Brief descriptions of quality control, quality assurance and measurements of total ozone at Norrköping and Vindeln for the years 2012 up 2015 are reported in the following chapters. 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 to keep them as short as possible. The lists are also useful to consult in case something odd appears in the analysis of data.

Plots of the daily data are presented in chapter 5, and the daily standard lamp test values in chapter 4. Monthly values of total ozone for all years are presented in Appendix B and daily values for the years 2012-2015 in Appendix C. Older values and instrument status are reported in earlier reports see References in 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 #6 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. Usually, via the travelling reference Dobson #65 (USA) and the regional standard Dobson #64 kept in Hohenpeissenberg, Germany.

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

The strong ozone depletion that affected the Arctic in the spring of 2011 was later analyzed by Petkov et al. (2014). Data from both Vindeln and Norrköping was used in the analysis.

The observations of total ozone have also been used for validation of satellite algorithms for total ozone observations, Bak (2015) and they were also included in a large reanalysis of ground- and satellite-based data set of total ozone for the period 1970-2012, van der A, Allaart, and Eskes (2015).

Another application where our data was used was in a study of the UV and it´s relation to global solar radiation, total ozone column and aerosol optical depth, De Bock et al. (2014). A similar study using satellite reflectivity data was done earlier by den Outer et al. (2012). If the UV is measured in two wavelength bands one in UV-A and one in UV-B region these data can be used to estimate the total ozone. A study on this using a simple broadband meter was done by Danielsson et al. (2013). The method was validated versus our observations of total ozone.

4. Instrument status

Most of the tests of the instruments are based on the use of two types of lamps, viz. the mercury lamp and the standard lamp. The mercury lamp is a low pressure lamp containing mercury, which is vaporized when the lamp is in operation and the mercury atoms are forced to emit radiation. This radiation is emitted at well-defined wavelengths in the UV and the blue region of the spectrum. The instrument is aligned spectrally using the emitted UV-wavelengths close to 302 nm and 312 nm.

The standard lamp is a halogen lamp that is operated at specified current and voltage. This type of lamp is known to be stable in irradiance for many hours of operation. The spectral characteristic is similar to a black body radiator and the relative spectral distribution, which is measured by Dobson and Brewer instruments, is assumed to be stable for a long time. Therefore, by measuring a standard lamp one is able to monitor changes in the instrument relative spectral responsivity in-between the calibrations.

The standard-lamps used for the Brewers usually have a life-time of one to two years. They are used a number of times every day. The Dobson lamps on the other hand are not operated as frequent, normally once a month, and therefore last longer.

4.1 Brewer #128

The latest comparison of Brewer #128 was done at the site in Norrköping in August of 2015. The change relative the previous comparison in the year 2012 was not so large, although clearly visible in the standard lamp tests, Figure 4.1. The calibration resulted in a slight adjustment of the constants. These and older comparisons are compiled in Appendix D.

The service during the calibration included lamp exchanges and replacement of the top plastic window. The old one had been foggy and it was time to check the rubber sealing between the window and the metal case.

The output of the standard lamp seems to degrade rapidly using the new type of halogen lamp, see Figure 4.1. The standard lamp test is done a number of times every day 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). A change in the R6-value by 12 units roughly corresponds to 2 DU.

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. For a long period of time (2008-2014) the R6-value has been relatively stable. The sudden jump in mid 2008 was most probably due to a change of the standard lamp rather than a change in the instrument responsivity.

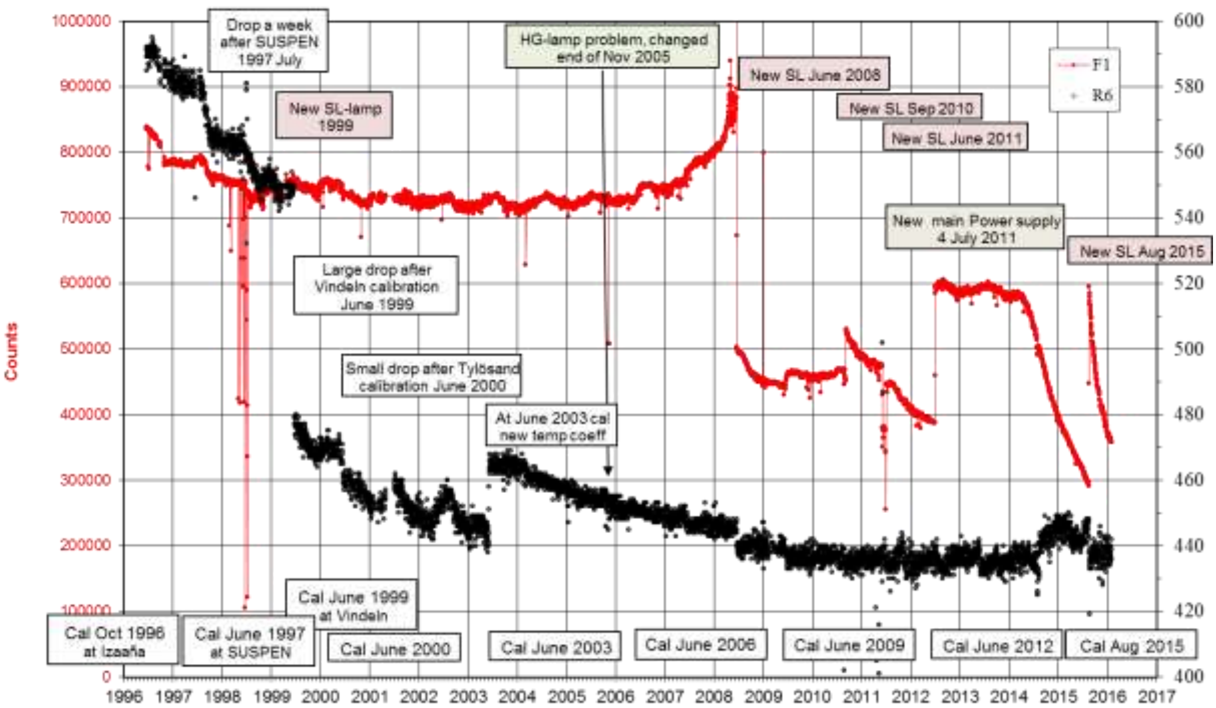

Figure 4.1 Standard lamp test value R6 (black) *for Brewer #128 over the period 1996-2015. The large change after the calibration in 1999 is clearly seen. Times for intercomparisons* (IC) *are noted as well as some lamp changes. The red dots show the "output" of the standard lamp.*

From the summer of 2014 up to the calibration the next summer the R6 values were slightly elevated. After the calibration and service in summer of 2015 the R6-values went more or less back to the previous level.

The red markers in Figure 4.1 show the standard lamp output as measured by one of the slits (wavelengths). In the early years there was a slight yearly variation probably due to some temperature dependence in the output.

In later years the output has been more variable. In recent years the introduction of a new lamp type gave a decrease in the output. If this have any serious implications on the measurements is too early to tell. The test-values discussed below still show a proper behavior although there is a slight increase in scatter. But, that is due to the lower output of the new lamp type.

Another test of the 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. The minimum time interval to be able to separate two photons 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. As the count rate increases the probability for photons to arrive within the dead-time increase and this will cause a non-linear response.

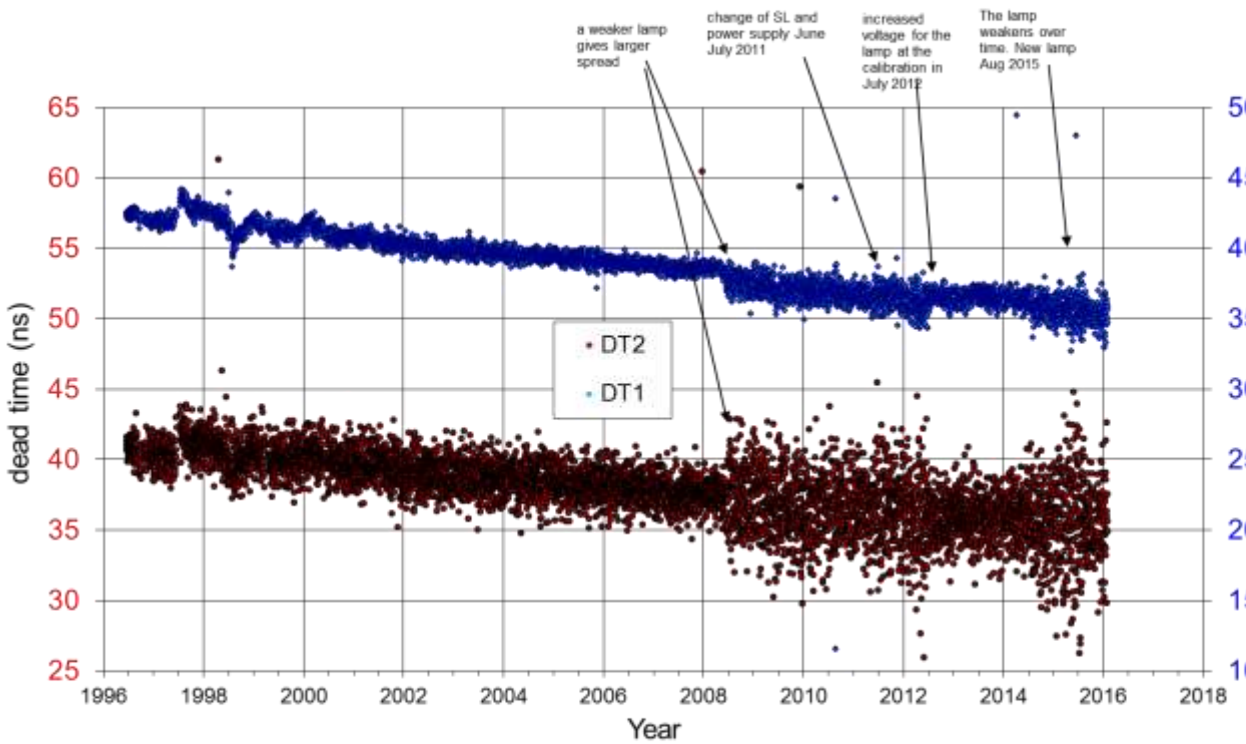

Figure 4.2. Dead-time (ns) *for Brewer #128 for the period mid-1996 to 2015. The scatter increased in 2008 when a weaker lamp was introduced.*

However, to some extent the problem can be corrected for by a statistical approach. 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 then 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 36 ns over the period 1997 to 2015.

In late 2008 the scatter increased due to the fact that the new standard lamp type used is weaker than the previous ones. This increases the random scatter. To reduce the scatter the current through the lamp (by increasing the voltage over the lamp) was slightly increased in 2012. By time the scatter has increased as the lamps ages.

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 exit 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 of the photon counts for each slit (wavelength) of the 20 cycles can be regarded as recorded simultaneously at the mean time of the cycles.

The mask moves very rapidly and the photon counting must be done when each slit is fully exposed. This demands a good synchronization between the mask movement and the reading of the PMT. 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. The outliers in Figure 4.3 are probably due to random disturbances in the measurements. If the ratio systematically (for a number of concurrent observations) deviates from 1 the synchronization must be adjusted. The parameter to do this is called the shutter delay time. Also this test shows a slight increase in the scatter after the introduction of the weaker standard lamp.

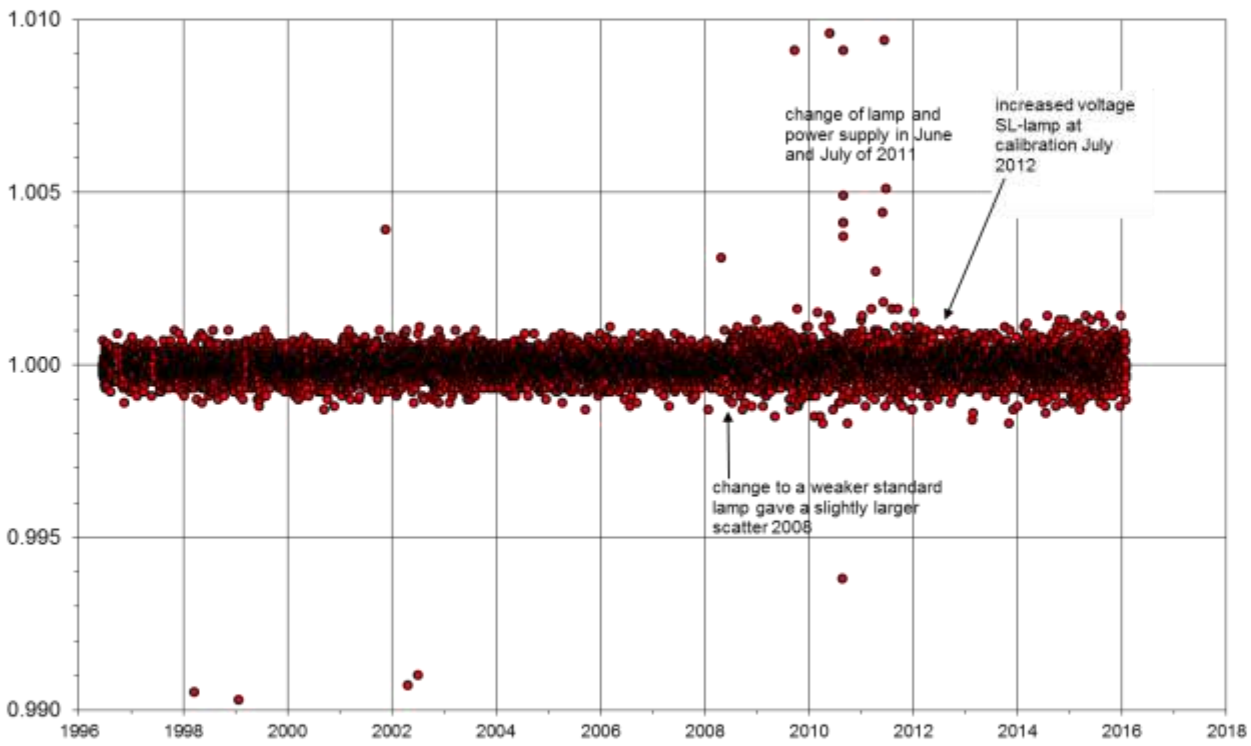

Figure 4.3. Run and stop test for Brewer #128 for the double slit position of the shutter mask for the period 1996-2015. A slight increase in the scatter and also in the number of outliers can be noticed from mid-2008

4.2 Brewer #6

The Brewer #6 status is tracked by doing the same type of tests as for the Brewer #128. Therefore, the descriptions of why and how the tests are done are not so detailed in this section. As previously described most tests are performed on a daily basis, while comparisons and service are done and at longer time intervals. Data on the results of these can be found in Appendix D.

The change in the responsivity of the Brewer #6 instrument is tracked using the standard lamp tests, Figure 4.4.

With similar routines as for Brewer #128, 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.

Figure 4.4. Standard lamp test value R6 for Brewer #6 over the period 1999-2015. Comparisons (IC) *and lamp changes are noted as well as comments to some outliers.*

Mostly, Brewer #6 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 thus 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 take some time for the lamp to burn in giving rise to a slight drift in the results.

Since 2004 the R6-values have mostly shown a slow decrease. This is typical for the instrument type and within limits. At the times of intercomparison the instrument has been serviced. This has usually resulted in small shifts in the R6-value. At the intercomparison in early 2011 the temperature coefficients were changed causing a small jump in the R6-value. From about 1820 to maybe 1813, also see Figure 4.9.

During 2015 there has been a relatively faster than normal decrease in the R6-value. This may be connected to the use of another type of standard lamp.

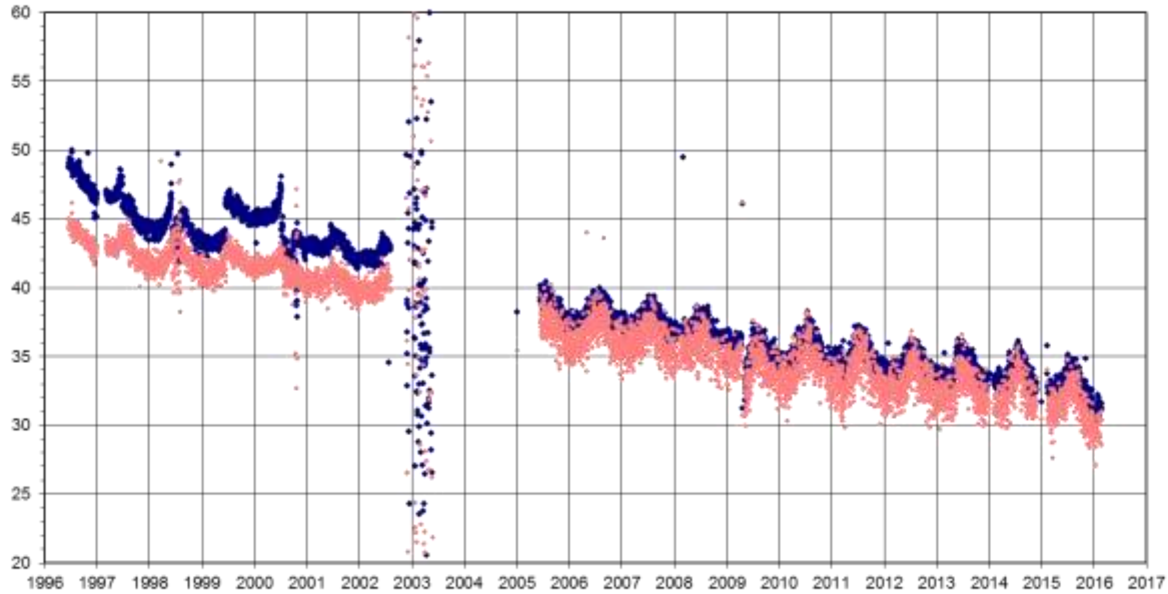

Figure 4.5. Dead-time (ns) for Brewer#6 for the period 1996-2015.The two colors are for a low and a high intensity respectively.

The dead-time of the Brewer #6 has decreased over the period 1996 to 2015, Figure 4.5. There has also been a clear yearly cycle. This is probably due to 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 (35 ns) lower value of the dead-time (earlier 45 ns) was then applied after the intercomparison. Fortunately, the measurements are not very sensitive to this number.

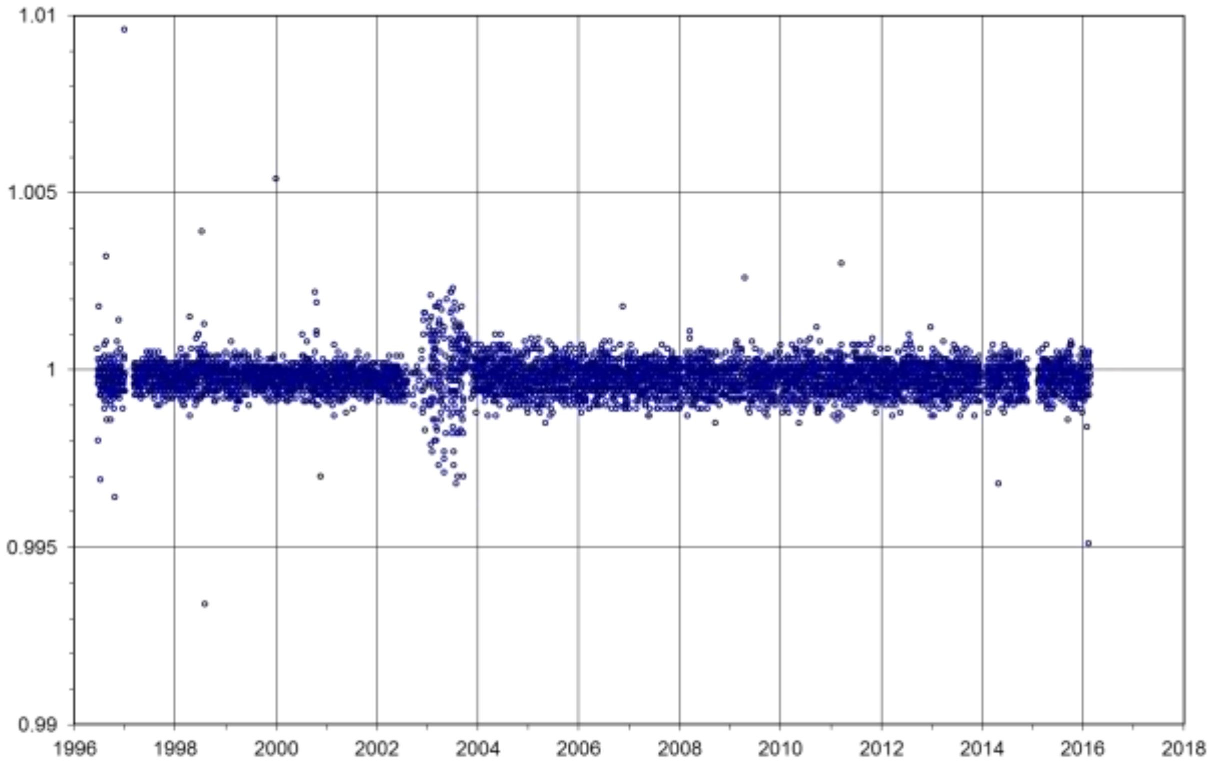

Figure 4.6. Run and stop test for Brewer #6 for the double slit position of the shutter mask for the period 1996-2015 Note the problems in 2003, when the signal was weaker and thus gave a larger noise.

The run and stop test of Brewer #6 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 giving a weaker signal. This caused a larger noise in the data.

Looking carefully, the average ratio for Brewer #6 is not exactly 1.000. By eye it seems to be slightly lower, maybe 0.9998. Compare to the result of Brewer #128, Figure 4.3, where the average of the ratio is very close to 1.0000.

4.3 Dobson #30

In mid-June 2010, the Dobson #30 was sent to Hohenpeissenberg, Germany, for a major refurbishment and upgrading. The mirrors were replaced, which means that the instrument practically became a "new" instrument after alignment and adjustments. Furthermore, the electronics were replaced with today modern technique. Part of this upgrade and calibration is shown on https://sites.google.com/site/dobsonozonecalibration/

The "new" Dobson #30 was calibrated using Dobson #64 as reference during 3-16 July 2010. The initial standard-lamp tests indicated stable calibration level since previous calibration in 2007 and no change of the 2007-2010 data was necessary. The final calibration showed less than 0.5% in AD and CD wavelength and no μ-dependency. New calibration levels were defined for the future.

Data from Dobson measurements are delivered to WOUDC database, Toronto, Canada. Standard and mercury lamp tests are made once a month. The standard lamp 30Q1 is used every month. The lamp 30Q2 was used twice a year until it broke down in June 2010. It was than replaced by the lamp 30Q4. The lamp 30Q5 is used once a year. The lamp in holder

30Q2 was replaced by a new lamp during 2015 and has been used together with lamp 30Q1 every month. After the intended calibration at Hohenpeissenberg in 2016 it will be one of the standard lamps of Dobson #30. Luckily, nothing spectacular has happened as can be seen from the lamp test results in Figure 4.7. A slow change can be seen for the standard wavelength pairs A and D in 2009. The more sensitive wavelength pair C' is not used for standard observation and has not been calibrated since Arosa 1996.

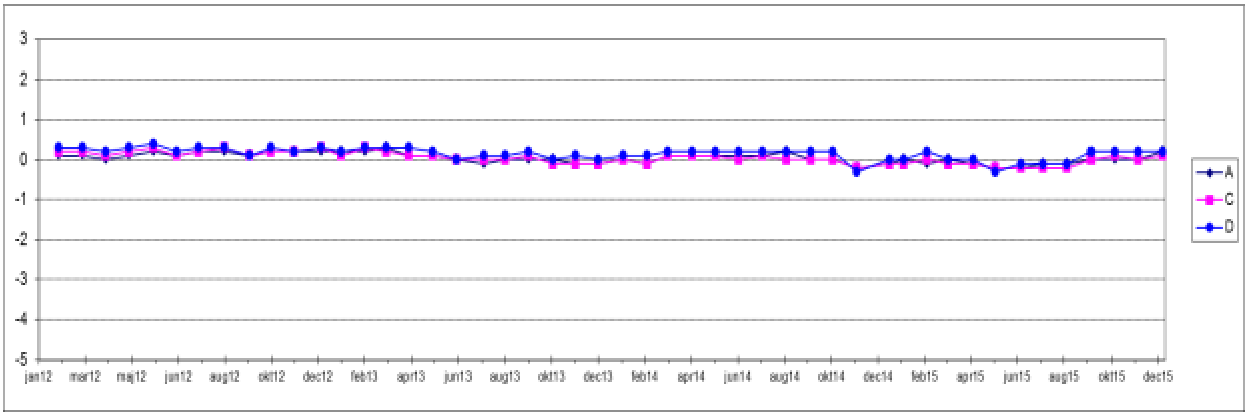

Figure 4.7.Correction coefficients based on the Dobson standard lamp tests (30Q1) for the period Jan 2012- December 2015. The various lines denoted by letter A, C and D refers to the used wavelength pairs.

4.4 A new house for the Dobson #30 and ozone equipment in Vindeln

For quite some time, the small hut used for housing the Dobson instrument, calibration lamps and the Brewer computer has been in a poor state. In particular, the roof started to leak and water is a risk factor that may cause severe damage to the delicate instrument.

Consequently, a special project to refurbish the old hut or to rebuild another small hut was initiated in 2012. With additional support from SLU and Svartberget field station, it was possible to upgrade to a permanent small house for the ozone station.

Thereby, more planning and preparations were needed and it took longer time than initially planned. Eventually, in 2015 the new house was finalized and a grand opening ceremony took place. The new building will provide the necessary conditions for operating the ozone monitoring for many years in the future.

A new computer running the Brewer program under Windows7 using DosBox was also installed during 2015. The new house has also enabled excursions and school-classes to visit and be informed of the environmental monitoring; e.g. Skinnskattebergsskolan, lärardagarna på Umeåuniversitet, Vindelns folkhögskola, Burträsk naturbruksgymnasielärare samt Waldorfskolan i Umeå.

	
Opening ceremony 2015-09-21 performed by Tomas Lundmark, Dean of the forest faculty, Swedish university of agricultural sciences (SLU)	Inaugeration participants in front of the new Dobson house. This southfacing special designed front construction allows Dobson to measure standing indoor in zenith and direct modes when front windows are opened.

5. Observations

In this section the daily data are plotted as one graph per year and site, Figures 5.1-5.8. 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.

During the period 2012-2015 the total ozone has varied a lot, which is typical for high latitudes. The first three months of 2012 the total ozone amounts were in general low. An interesting episode with thick ozone layer occurred in early April with values around 500 DU. For the rest of the year the amounts were close to the long-term averages

The beginning of 2013 presented higher than average values with the exception of a period late February and early March. And the rest of the year was close to average with one exception November.

The year 2014 showed a number of periods with higher and with lower total ozone. Centered around early March was a period with low values than normal. Also late May and early June had thinner than normal ozone layer. The general variation in 2014 was relatively slow if compared to the variation pattern of 2015.

The total ozone of the year 2015 shows a large variability between consecutive days (saw tooth pattern). It corresponds to the rapid migration of polar low pressure systems that came with westerly winds from the Atlantic during most of the year.

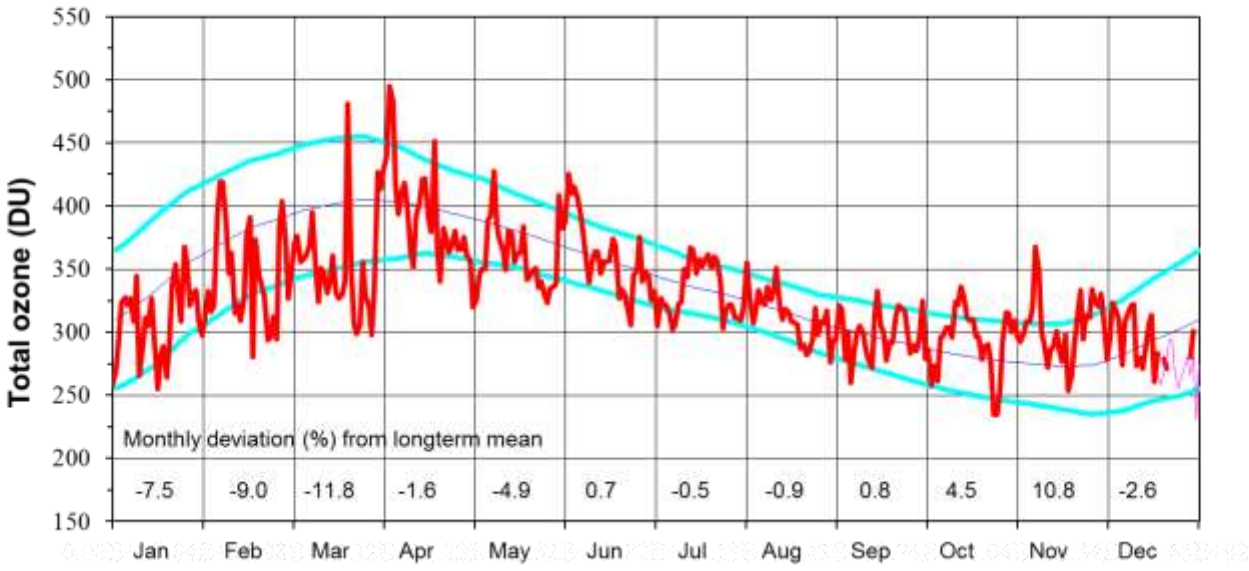

Figure 5.1 Daily 'noon' values of total ozone (red) recorded by Brewer #128 at Norrköping in 2012. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale.

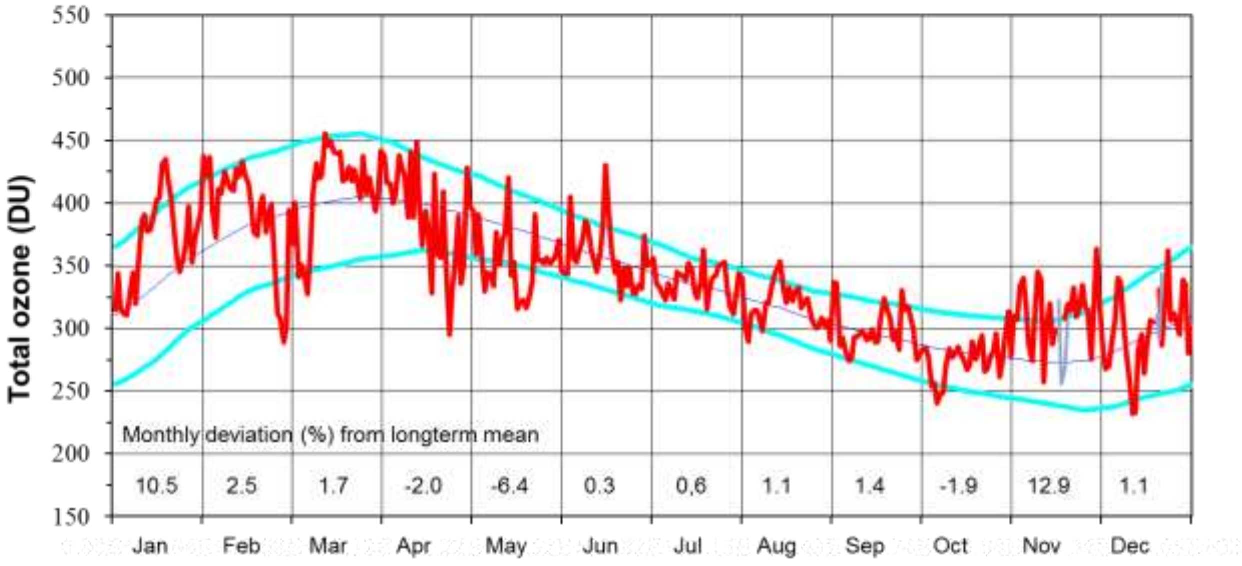

Figure 5.2 Daily 'noon' values of total ozone (red) recorded by Brewer #128 at Norrköping in 2013. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple).

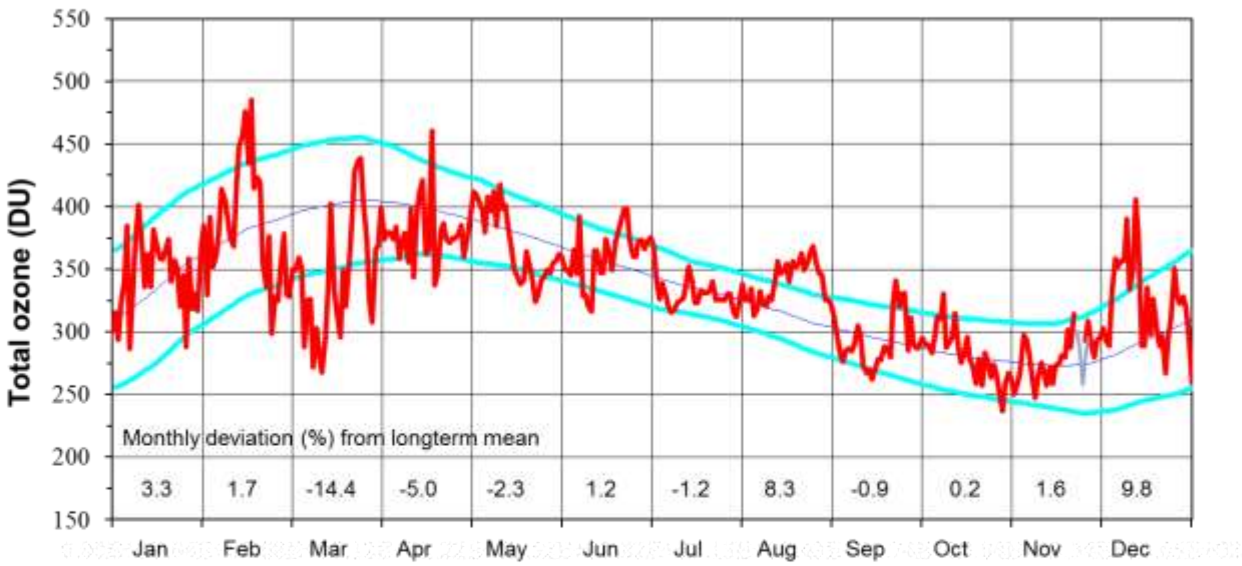

Figure 5.3 Daily 'noon' values (red) of total ozone recorded by Brewer #128 at Norrköping in 2014. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple).

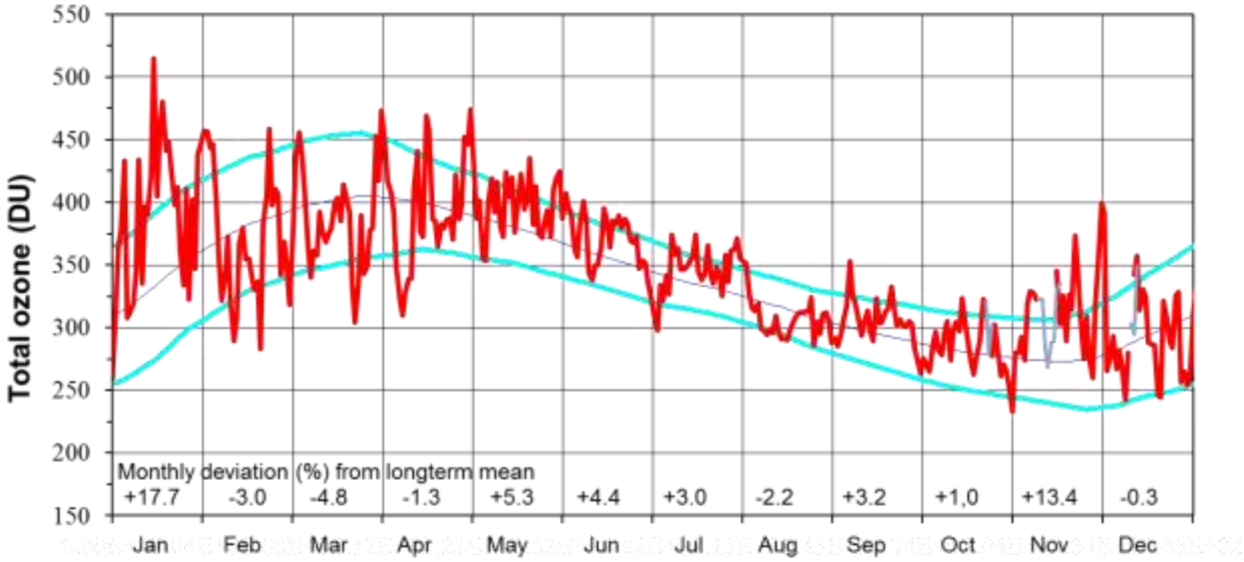

Figure 5.4 Daily 'noon' values (red) of total ozone recorded by Brewer #128 at Norrköping in 2015. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple).

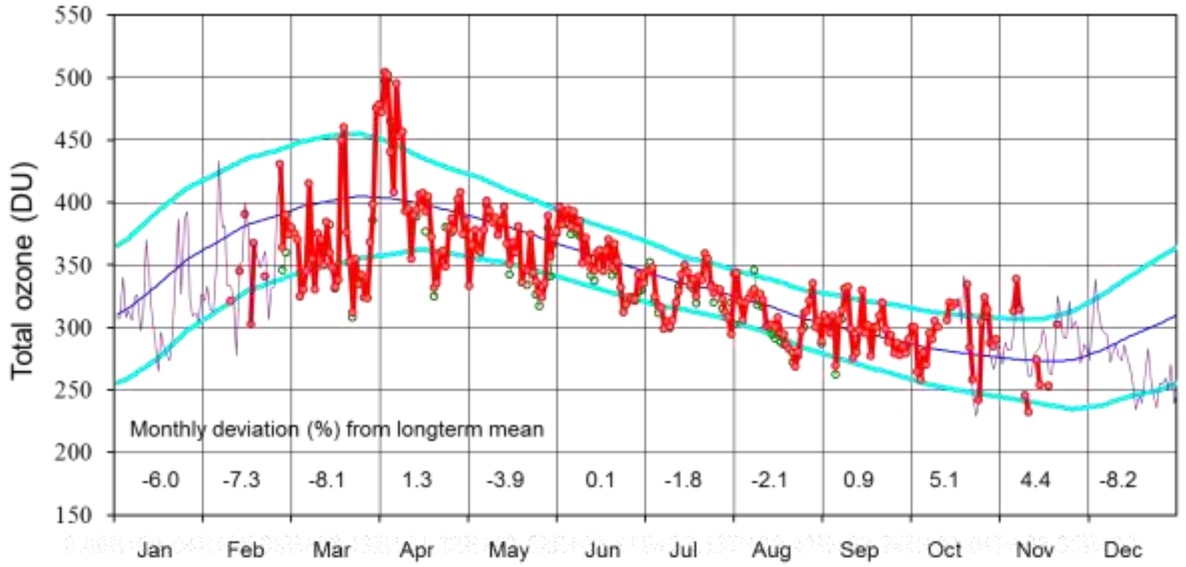

Figure 5.5 Daily 'noon' values of total ozone recorded by Brewer #6 (red) and by Dobson #30 (green) at Vindeln in 2012 Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple line).

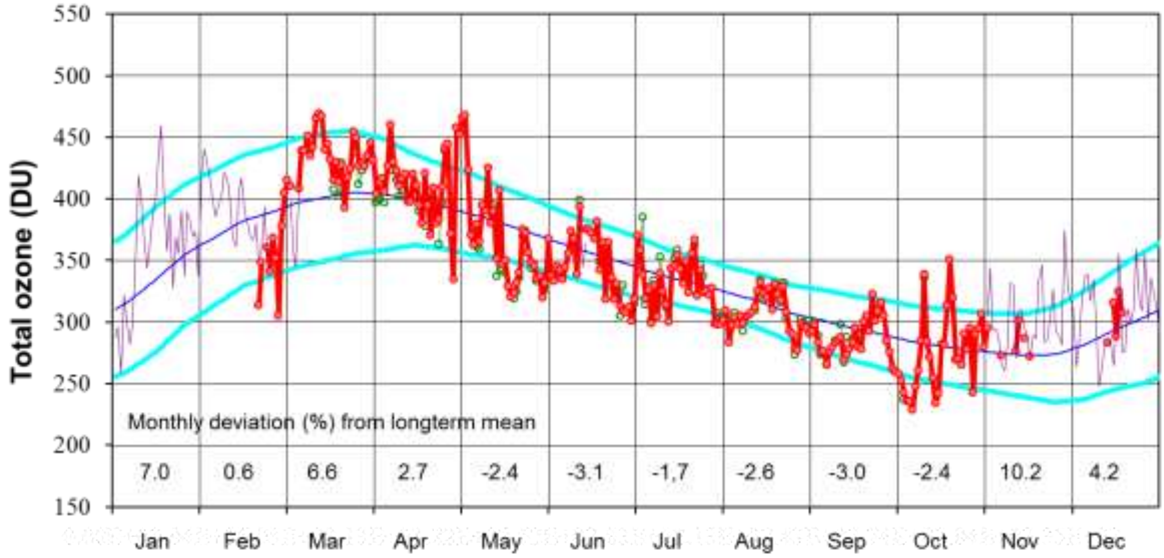

Figure 5.6 Daily 'noon' values of total ozone recorded by Brewer #6 (red) and by Dobson #30 (green) at Vindeln in 2013. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple line).

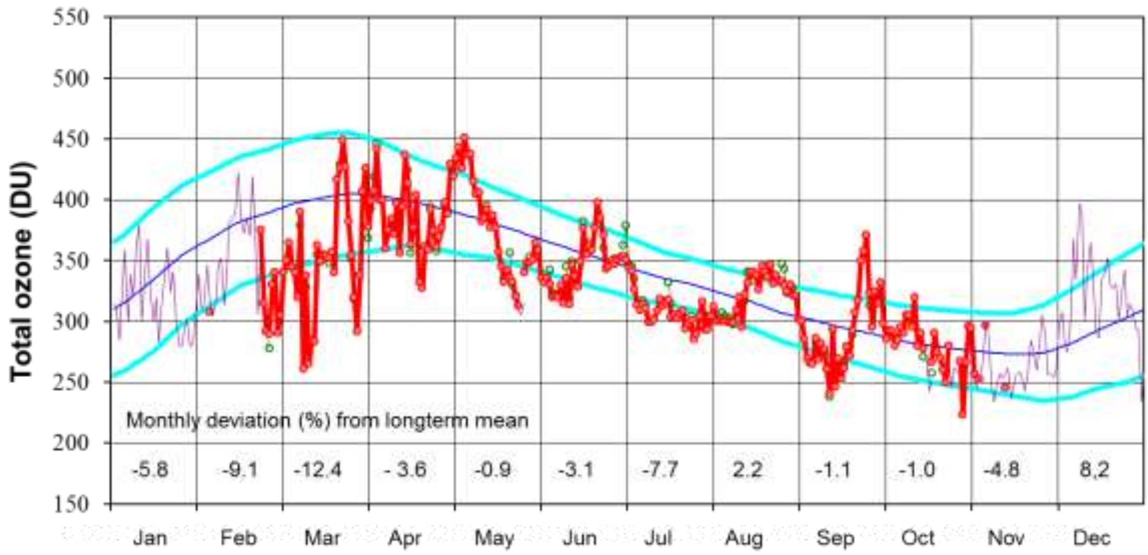

Figure 5.7 Daily 'noon' values of total ozone recorded by Brewer #6 (red) and by Dobson #30 (green) at Vindeln in 2014. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple line).

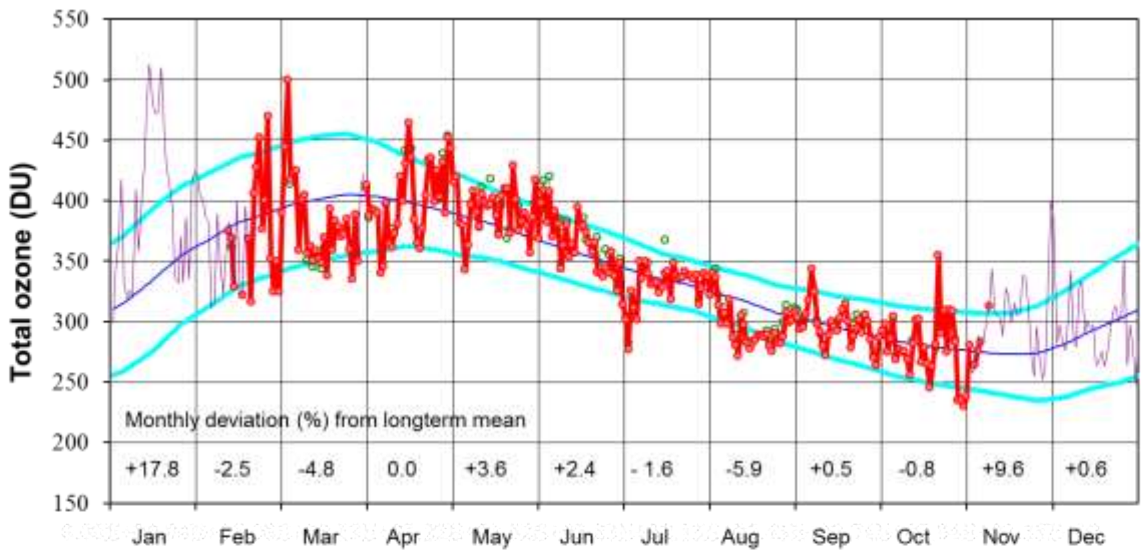

Figure 5.8 Daily 'noon' values of total ozone recorded by Brewer #6 (red) and by Dobson #30 (green) at Vindeln in 2015. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple line).

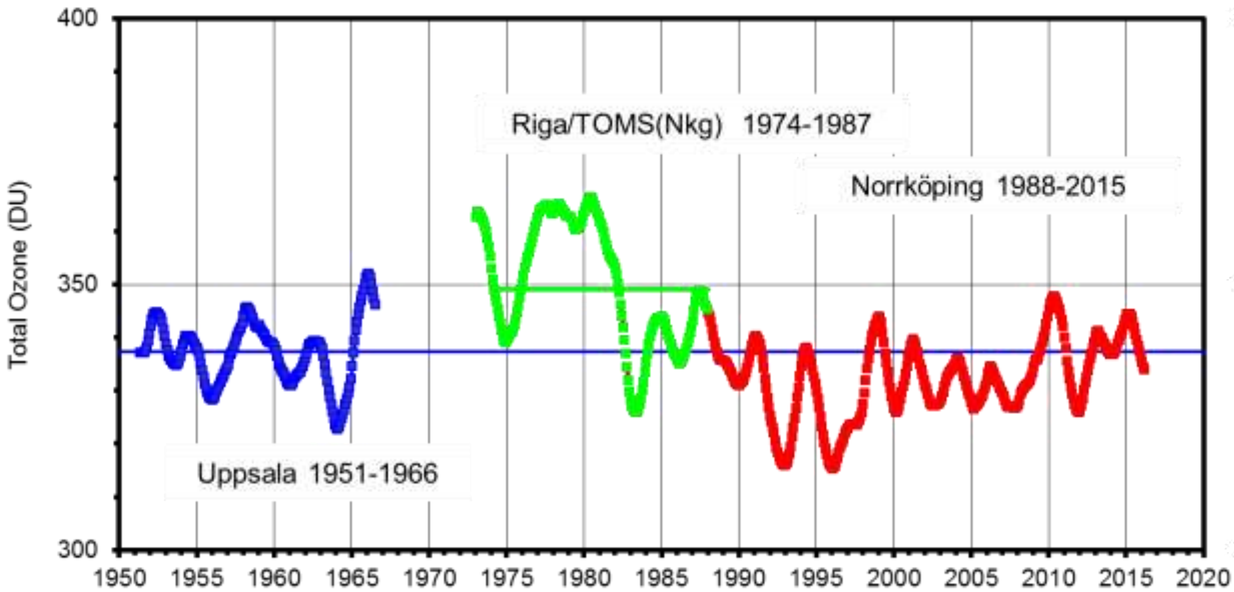

Figure 5.9 The long-term variations of the total ozone in Uppsala 1951-1966 (blue), Riga+TOMS 1974-1987 (green) and Norrköping 1988-2015 (red). The smoothed lines are based on monthly mean values that have been filtered by a two-year triangular filter. The blue horizontal line is the average from Uppsala.

6. Conclusions

The monitoring of the total ozone at Vindeln and Norrköping has revealed the expected amount of good quality data. Despite some problems the monitoring delivers daily data for the time of year when the solar elevation is acceptable for measurement. The daily data are stored and available at “Datavärdskap” at www.smhi.se and also at the WOUDC (World Ozone and Ultraviolet Data Centre, Toronto, Canada).

As was shown in Table 5.1 there is no significant trends in the total ozone over the period 1983 to 2011observed at Norrköping. Therefore, during the last decades the total ozone over Sweden is neither decreasing nor increasing significantly.

On a global scale and for a longer period of time, the total ozone decreased from the 1960-ties and 1970-ties reaching a minimum during the 1990-ties. Some of the lowest values observed in the 1990-ties were related to the volcanic eruption of Pinatubo, Philippines. The effect of Pinatubo lasted for a couple of years, thereafter the global total ozone seems to have stabilized and it is now expected to recover. These expectations are based on the fact that the ozone depleting substances have been banned according to the Montreal protocol and their concentrations in the atmosphere have decreased and thus this is likely to have an effect on the atmospheric total ozone.

Nevertheless, the ozone-related processes in the stratosphere are relative slow and the natural spatial and temporal variations in ozone concentration are large and therefore it cannot be expected to see an immediate rapid response in the stratospheric ozone. Thus, a significant recovery may not be stated within the immediate future of a few years. Instead, a substantial part of a century might be needed, with high quality ground based ozone observations.

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Appendix A

Events that affected the monitoring during the period 2012-2015

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.

2012-06-25 calibration versus Br#017. PC was changed and a new version of the software introduced on Windows XP.

2012-07-04 Stop. Problem with “out of range” in sub-string during UV-scan. This problem occurred now and then. It seems that the new software was not able to handle the special UV-scan routine needed by Brewer#128. To avoid these problems the UV-scanning was removed from the schedules. This solved the problem. However, no more UV-scans were taken.

2012-07-11 at 8.50 UTC. Desiccant exchange big box.

2012-08-02 at 6.25 UTC. Desiccant exchange big box. A spider was removed.

2012-10-28 Time correction by one hour (at 12.20 UTC) as the computer had changed automatically to winter-time.

2012-12-22 at 9.50 UTC Polar kit on

2013-05-09 at 6.10 UTC Polar kit off

2013-05-22 stop at midnight (change site on the screen?) restart

2013-05-24 stop at 23:40 out of string space in HL.rtn Restart at 10.30 UTC. Siting was checked. Perfect!

2013-08-12 at 4.45 UTC cleaned big wheel. Checked siting perfect.

2013-10-04 at 7.40 UTC. Desiccant exchange big box.

2014-01-12 at 9.50 UTC Put polar kit on. It had shrunk so it cracked in one corner.

2014-01-13 at 8.40 UTC cleaned big wheel.

2014-04-13 at 11.35 UTC Polar kit off, windy.

2014-06-02 at 6.00 UTC Desiccant exchange big box.

2014-07-13—14 Stop, azimuth at midnight. It seemed that the power supply in the azimuth tracker failed.
At 6.45 power supply removed. Brewer started without azimuth tracking.
It was detected that the zener-diode had burned on a board. New one was purchased and replaced.
2014-07-17 at 12.12 UTC restart.

2014-08-04 Stop. Restart at 11.30 said it couldn’t see the HG-lamp.

2014-08-05 Stop. Same as the day before. Contacted IOS.

2014-08-06 Stop. Same as before. Suggestion from IOS to change the micrometer #1 default setting. Did so.

2014-08-07 Seems to have solved the problem. Desiccant exchange big box and in spectrometer.

2014-09-30 at 5.30 UTC. Desiccant exchange big box.

2014-12-28 at 9.20 UTC. Snow removed from quartz window. This snow had prevented observations the day before, which was a sunny day.

2015-01-11 at 11.30 UTC Put polar kit on.

2015-04-08 at 6.45 UTC Polar kit off.

2015-04-09 at 13.40 UTC. Desiccant exchange big box.

2015-04-15 at 5.35 UTC. Siting was checked. OK!

2015-08-16 Brewer calibration starts
2015-08-17 Desiccant exchange big box and in spectrometerbox. New HG- and SL-lamps. A humidity sensor inserted. Testing new computer with Windows7 and DosBox.

2015-08-21 Stop at midnight. Restart at 10.20 UTC.

2015-09-02 Stop detected at ~ 10 UTC. Cables twisted. Restart at 11.51 UTC.

2015-09-11 08.30-09.06 UTC. Copied files. This seemed to interfer with the program during HG.rtn. The micrometer screws jammed and had to be reset manually. However looking into the D-file revealed that the problem had occurred earlier.

2015-09-15 at 10.50 UTC the program produced strange values. Stopped the Brewer and made a reset.

2015-09-18 Brewer output strange may be caused by opening the D-file during operation. Reset and restart at 10.15 UTC.

2015-09-25 testing to open D-files and see what happens. No clear conclusions could be made.

2015-10-02 at ~12 UTC the computer, which always has been a stand-alone machine, was connected to the Internet. A virus protection program was installed. The program seems to run OK at a check at 16.45 UTC.

2015-10-20 Stop. At 11.00 UTC noted that the Brewer had been standing and doing no observations since last day. The cause could be that Win 7 needed some updates (# 18).
The Brewer-program refused to run properly. "File not found in 3241" several times. Printed Run in the DosBox-window. As it stopped next time printed "cont" in the DosBox window a number of times and then it went on. Made a reset at 11.26 UTC and after that started a schedule. 11.32 OK.

2015-10-22 Noted a Stop at 7.50 UTC. Brewer pointed in wrong direction. Made Off/On on tracker and Brewer. Then reset. Something was in error. Suspect the board with the Zener-diode. Restart at 08.00UTC without tracking working properly.

2015-10-23 Nice weather; made two direct sun observations manually. At 12.27 UTC Restart after that Jan-Erik Karlsson had changed the diode. The previous soldering had not been properly done. He also repaired the spare board Zener-diode. 12.50 UTC Desiccant exchange big box. At 13.00 UTC made AZZESI to check the tracking. OK! Restart.

2015-10-25 Checked tracking seems OK.

2015-11-04 Stop. Since Nov. 3. Reset and restart at 08.50 UTC. Suspect that the problem occurred when file was checked the other day. The restart did not work. The micrometer screws were stuck and had to be reset manually. Opened lid of Brewer and also exchanged the big box desiccant. Restart at 10.00 UTC.

2015-11-09—15 Brewer program halted. As Weine was in Vindeln and in Sodankylä no observations were done for this period. We tried to solve it over the telephone but did not manage to do that.

2015-12-11 Stop. Micrometer screws jammed. Had to be reset manually. Restart at 11.00 UTC.

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At the following occasions, dates, the Brewer #6 or Dobson #30 in Vindeln have had issues 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 as well as an explanation of missing data.

2012-03-14 Power break 12:00 – 14:00 SNT

2012-04-30 Sun tracking Brewer ok

2012-05-23 Brewer running wrong schedule changed from day-number: 148 to 144.

2012-06-28 Desiccant changed big and small box

2012-10-11 Brewer tracking wrong. Restart and OK.

2012-12-13 Problem with network. Restart of PC helped. Brewer running wrong daynumber 352 instead of 348. Corrected.

2013-02-07 F-secure updates. Started 08:45 Stop and restart at 12:30

2013-03-18 Brewern gave negative DS-values despite sunny weather. Test showed that suntracking was OK. After a while everything seemed OK.

2013-03-22 Brewern gave lower values than Dobson. Unusual, as it uses to be the other way around.

2013-03-26 Brewer one day off in schedule. Corrected.

2013-04-09 Brewer one day off in schedule. Corrected.

2013-04-19 Brewer one day off in schedule. Corrected.

2013-05-20 Power-breaks. Internet disturbances. Fuses broke in the hut. Power returned in the afternoon. Measurements could proceed.

2013-05-21 Power ok but no internet connection. No problems for Dobson and Brewer.

2013-05-22 Power break before noon. PC and Brewer restarted and OK.

2013-07-5: 2013-07-08 Martin Stanek, IOS, at Vindeln for service and calibration of the Brewer.

2013-07-09 Very high SO_2 18.1 DU.

2013-07-10 Values back to normal.

2013-08-07 Power-break due to construction work; the new hut.

2013-09-16 Brewer twisted cables and stopped. Re start at 10:30 UTC no problems.

2013-09-21 Brewer twisted once again. The big wheel was cleaned. It didn't seem so dirty. Restart of the Brewer and computer and OK.

2013-09-24 Brewer off in schedule. Corrected. Azimuth discrepancy -3

2013-10-10 13:10 UTC. Computer stuck when Windows closing. F-secure update. Restart and it works.

2013-11-18 The storm Ellen created some problems. Building construction fell and almost hit the Brewer and caused power break. Restart of Brewer at 08:30 UTC. Maybe the values are affected by the building construction nearby.

2013-12-23 Suntracker problems for the Brewer. The instrument will not rotate correctly and it produces strange sounds. Therefore, Brewer kept off over Christmas.

2014-01-16 Suntracker restarted it seems to work. Azimuth Discrepancy – 1521.

2014-02-25: 2014-02-25 Weine J and Thomas C on visit. The Brewer was brought indoors for inspection, cleaning and change of desiccant.

2014-03-26 Brewer cables twisted. Restart and OK. Azimuth dis: -62

2014-05-26 Lightning at Vindeln made the fuse to break. The residual-current circuit breaker (sw. jordfelsbrytaren) cut the power and the Brewer had twisted its cables. As the power came back the Brewer had problems to restart. Restart of both Brewer and computer helped.

2014-06-03 Brewer off in schedule. The PC may have been without power and restarted.

2014-06-04 Brewer twisted and fuses burned. Restart as something in the program was stuck and only ZS-obs despite cloud-free weather.

2014-06-05 Brewer misses the sun. Close program. Made a reset followed by AZZE. ”Zeroing failure”
Horizon old – 10 New -10
North old -454 new -454
Remote 5 step.
Restart of the Brewer and the computer gives the same result. Open the Brewer azimuth tracker box and notes that the safe is not properly in. Another AZZE – and it works.

2014-06-06 New thunder and lightning. But, everything seems to work.

2014- 07-07 Brewer on the wrong schedule. Schedule daynumber should be 188 was 191. Corrected.

2014-07-14 Heavy thunderstorm. Short power-breaks but both Brewer and PC restarted OK.

2014-07-18 Lightning and power-breaks during the day. PC and Brewer restarted OK.

2014-08-04 More thunder and lightning on Friday. The Brewer-computer disabled. No observations.

2014-08-05 The Brewer is connected to the old DOS-machine and restart the observation. Unfortunately, with the old calibration constants. Diskettes used to copy data files.

2014-08-07New calibration values put on the DOS-machine during the day. More lightning caused power off, Brewer restart at 15 UTC. But, new power breaks in the evening.

2014-08-08 Power breaks during night. Restart of Brewer at 08:50 UTC.

2014-08-12 Computer repaired. New power supply. Restart Brewer at 12:00 UTC.

2014-09-01 Siting SI at 09:50. Brewer slightly off. Old – 10 New -7

2014-09-18 Power break at Vindeln 09:00 – 10:00 SST. The Brewer and computer had to be restarted several times to get it running. New several planned power breaks during night and morning. Therefore the Brewer was closed down.

2014-09-19 Re start of the Brewer at 13:30 UTC. The suntracker stood jumping without moving properly. After several restart of PC and Brewer it seemed to work. Unfortunately, no observations as the new hut in the way.

2014-10-15 Power break during day caused the Brewer cables to twist. This wasn't detected until 17/10 when a restart was made. OK.

2014-11-11Brewern stopped. It had not twisted and the fuse was OK. Try to restart but the tracker just jumps, After several restarts and manual turning of the tracker the observations could be restarted.

2014-11-28 The problems from 11 Nov repeated. Restart attempts done several times. But no success. Decided to power off and leave until Monday.

2014-12-01
New attempts to get the Brewer running. Cables checked, wheel cleaned in the azimuth box. The azimuth tracking starts ok but there is a position where it becomes stuck and starts to shake, Closed the Brewer and waited for a new day.

2014-12-09 Check power supply- OK.
Opened the brewer box and pulled the electronic cards out and in. No change.
Changed the signal cable between Brewer and PC. No change.
The program starts, there is contact. But after a while there is COM Error and the tracker starts jumping.
Also tried another computer. Suspect a card problem.

2014-12-18 09:00 SNT. The Brewer brought in to the hut for new testing. Does not help. Probably a electronic board problem

2015-02-10 Weine J made a visit. Testing the Brewer and changes cards. At last it is working again.

2015-02-16 A fuse has burned in the hut. The Brewer has unfortunately been standing the whole day. Restarts without any problem.

2015-04-28 Some power-breaks 27/4. Brewern and PC had restarted properly.

2015-05-21:2015-05-22 The electrician working on the new hut made some power-breaks during these days. Brewer had no power during night.

2015-05-26 The electric and IT have finished their work. The Brewer PC-moved to the new hut (house) and connected.

2015-06-29
The electrician was not finished with his installation so new power breaks during the day.

2015-08-06 Brewer stop. Looking for the sun but stuck. Restart of the program helps. OK.

2015-09-21 The new ozone house, opening ceremony.

2015-11-23 Restart of the program. The schedule daynumber off should be 327 was 332.

2015-12-07 Brewer was off. Old schedule tried to observe moon. Restart program and it measured the sun.

2015-12-14
Brewern pointed wrong. Restart of program and OK.

Appendix B.

Monthly values of total ozone (DU) for the whole period at Vindeln (1991-2015) and at Norrköping (1988-2015).

Table B1. *Vindeln monthly values of total ozone (DU). Italic values are largely based on satellite observations and may be uncertain. 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	*291.2*	*279.1*
2003	*346.7*	*317.6*	**335.4**	391.2	380.7	359.5	316.0	310.9	281.7	271.9	*283.5*	*292.2*
2004	*342.0*	*362.3*	397.7	372.2	385.2	364.7	330.1	304.4	290.9	271.0	*274.1*	*282.2*
2005	*338.6*	297.6	337.9	403.9	372.0	342.5	320.3	295.6	287.6	262.0	*264.4*	*294.4*
2006	*311.9*	402.6	426.2	**419.4**	379.0	339.7	313.5	289.0	287.3	269.4	*268.9*	*312.0*
2007	*359.9*	354.9	373.8	363.9	365.2	335.4	319.6	296.8	299.5	288.1	*270.2*	*289.7*
2008	*315.9*	331.2	418.8	372.4	365.9	342.3	325.0	309.8	280.0	**290.9**	*288.2*	*285.7*
2009	*375.6*	**436.8**	398.5	364.1	354.3	341.7	322.7	303.8	287.7	286.5	*291.3*	***277.3***
2010	*324.3*	*415.6*	412.3	379.8	384.6	365.9	312.9	307.4	292.6	290.0	*294.9*	***320.8***
2011	*349.7*	357.9	356.9	372.3	378.4	336.6	310.3	296.2	291.7	277.6	*285.4*	*320.7*
2012	*316.5*	352.7	368.8	403.2	364.2	356.0	328.5	307.2	297.5	294.7	*286.3*	*270.7*
2013	*360.1*	382.2	427.4	409.2	370.6	345.7	329.4	306.2	286.4	274.0	*302.2*	*306.2*
2014	*317.1*	*345.5*	351.3	384.3	376.5	345.3	309.3	321.4	291.9	277.8	*261.2*	*317.9*
2015	***396.5***	*370.5*	381.9	398.5	392.4	365.3	329.8	295.8	296.6	278.4	***300.6***	*295.7*

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
2006	294.9	391.0	406.4	**418.1**	379.6	340.7	**318.8**	318.7	288.6	273.4	294.0	283.0	333.5
2007	338.8	362.0	389.4	355.3	361.8	335.3	335.6	310.0	299.0	265.7	291.8	291.2	327.8
2008	324.6	320.9	411.7	381.2	364.9	347.4	328.4	308.9	285.6	284.8	285.3	283.0	327.3
2009	356.6	**425.8**	387.1	343.8	354.4	352.6	329.6	309.9	293.1	297.6	287.4	342.3	339.5
2010	341.4	395.1	407.8	398.4	385.3	369.1	324.3	323.3	312.9	296.5	**322.0**	**348.7**	**351.7**
2011	359.2	364.7	357.9	353.2	371.7	343.5	321.8	305.9	290.5	277.7	275.1	306.6	327.1
2012	311.2	345.7	354.0	391.8	360.5	358.1	333.0	310.9	296.9	293.4	304.0	287.2	328.7
2013	372.0	389.6	407.8	390.6	355.3	357.6	337.1	317.8	299.3	275.3	309.6	297.0	342.1
2014	347.6	386.3	343.2	378.7	371.0	360.9	331.1	340.5	292.7	281.3	278.5	322.7	335.9
2015	**396.3**	368.5	381.6	393.3	**400.1**	372.3	345.3	307.5	304.7	283.6	310.9	292.9	346.3

Appendix C.

Table C1. *Daily 'noon' values of total ozone (DU), Vindeln 2012, Brewer #6*

2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1			380.2	472.0	333.1	396.0	345.1	343.4	305.0	300.0		
2			375.0	504.4	366.2	381.9	345.8	320.2	295.0	264.4		
3			370.0	502.2	378.3	392.5	347.8	306.1	309.0	257.9		
4			325.0	440.3	361.9	394.0	324.8	320.0	269.1	280.0	313.0	
5			330.0	408.3	360.0	380.6	317.2	323.1	305.9	270.0	338.6	
6			345.0	495.4	378.1	392.6	315.5	327.2	313.2	295.0	314.3	
7			415.0	453.2	401.2	378.9	299.1	330.0	331.2	290.0		
8			355.0	456.6	393.4	384.7	304.6	323.6	332.1	305.0	245.5	
9		321.0	330.0	392.7	383.9	351.1	301.2	326.8	298.8	300.0	232.3	
10			375.1	395.0	387.9	372.0	305.6	322.1	275.7			
11			370.0	355.0	373.5	354.1	320.0	300.9	279.6			
12		344.9	350.0	389.9	384.7	347.3	329.2	301.4	297.6	306.1	274.2	
13			384.2	394.4	396.5	346.0	342.4	302.1	329.7	320.0	253.7	
14		390.5	360.0	406.2	366.8	360.0	349.7	300.2	295.0	317.0		
15			348.1	407.6	350.9	361.8	344.2	308.0	301.3	319.3		
16		302.3	332.4	392.8	368.0	345.1	333.7	295.3	277.0		253.3	
17		367.7	337.9	404.6	360.0	361.1	338.8	294.4	300.0			
18			449.7	372.5	381.1	370.2	325.0	285.8	300.3			
19			460.0	331.7	335.9	348.2	341.0	282.3	309.2	334.2	302.2	
20			375.9	335.0	347.2	367.1	338.2	279.6	320.0	284.0		
21		341.0	352.9	360.0	346.1	353.0	359.4	268.4	298.8	258.4		
22			312.3	361.5	374.7	332.0	354.9	280.6	288.1			
23			354.7	348.6	344.0	312.1	332.2	297.2	294.0	242.2		
24			334.2	380.0	336.4	318.4	327.4	311.1	279.1	304.1		
25			342.4	387.0	327.2	324.0	331.3	313.0	287.4	323.9		
26		430.6	324.0	377.8	323.7	321.7	330.2	321.5	277.8	314.5		
27		364.0	323.2	402.4	335.2	322.9	322.8	335.0	285.0	287.5		
28		390.3	368.4	408.3	389.0	342.3	311.9	300.0	279.4	284.9		
29		374.3	398.1	374.8	357.1	333.8	308.2	305.0	290.0	290.0		
30			475.7	384.7	370.7	335.0	294.5	288.6	300.0			
31			478.3		376.8		342.6	310.0				

Table C2. *Daily ‘noon’ values of total ozone (DU), Vindeln 2013, Brewer #6*

2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1			405.0	431.5	452.3	367.5	318.6	301.5	292.3	258.0	294.9	
2			415.0	404.2	466.0	337.2	370.0	309.6	297.8	252.2		
3			410.0	413.3	467.5	332.9	358.3	283.2	283.1	242.4		
4				416.7	423.3	345.0	338.1	297.6	275.9	235.9		
5				406.2	370.6	342.3	319.1	303.9	276.6	235.5		
6			408.0	426.2	362.9	334.5	326.2	298.1	266.1	228.8	273.0	
7			439.0	460.3	379.5	344.4	298.8	305.0	275.8	247.2		
8			439.0	429.6	365.4	355.3	329.3	298.7	279.1	260.0		
9			451.0	422.8	395.0	373.9	304.7	304.7	283.0	285.0		
10			435.0	410.3	390.0	367.4	339.2	306.1	285.3	338.7		
11			442.0	416.4	425.0	338.5	324.7	307.6	287.2	284.0	276.1	
12			466.0	420.3	379.9	393.2	314.5	311.9	269.0	271.1	301.9	
13			469.0	397.6	389.9		300.0	325.1	273.5	254.3		283.0
14			467.0	397.6	351.3	375.0	343.5	332.4	278.0	234.0	286.6	
15			439.5	420.0	406.7	375.3	346.1	323.5	283.6	241.9		315.4
16			444.6	411.0	347.5	372.2	354.3	319.8	295.0	281.8	272.3	288.0
17			431.7	395.0	349.8	367.6	343.2	327.2	280.0	280.9		325.0
18			415.0	380.2	328.8	381.6	330.9	310.0	277.6	313.6		307.0
19			429.6	420.6	320.4	342.3	349.3	330.7	300.0	350.4		
20		313.5	414.0	394.7	323.0	365.0	324.0	322.4	305.0	319.6		
21		348.5	427.1	370.2	332.0	318.5	355.9	317.4	292.6	269.5		
22			392.5	408.9	339.8	365.0	366.6	328.9	322.7	270.0		
23		360.5	417.0	380.0	375.3	335.9	321.0	307.6	301.2	265.0		
24		341.1	424.0	383.6	372.3	318.1	342.0	292.6	308.5	290.0		
25		368.4	454.7	409.3	356.3	330.8	324.0	290.4	315.9	277.9		
26		351.8	449.5	442.2	348.3	313.1	325.5	278.2	305.0	295.0		
27		305.4	426.5	444.7	346.1	309.2	322.0	276.9	285.0	242.3		
28		378.0	429.4	371.7	334.9	308.1	327.2	298.5	275.6	290.0		
29		359.6	426.2	334.2	337.0	312.2	298.5	296.5	262.3	294.2		
30			434.6	457.9	319.5	300.9	298.1	295.4	259.5	306.3		
31			445.4		331.4		297.8	290.0		279.8		

Table C3. *Daily 'noon' values of total ozone (DU), Vindeln 2014, Brewer #6.*

2014	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1			305.0	377.3	419.3	336.0	350.8	312.4	299.9	285.1	294.8	
2			340.0	399.0	434.4	331.7	343.4	300.0	285.6	292.6	256.4	
3			350.0	407.6	443.3	336.2	341.5	300.0	269.0	292.7		
4		307.7	365.0	442.0	425.8	330.0	326.3	300.0	265.8	280.0	252.5	
5			345.0	400.0	451.0	320.0	313.4	300.0	265.4	285.0		
6			340.0	400.0	437.3	320.4	309.4	299.7	285.8	295.0	296.6	
7			320.0	360.0	437.4	320.1	314.3	299.1	268.5	290.0		
8			389.7	375.0	415.2	329.6	311.0	299.0	281.9	305.0		
9			260.7	384.5	405.0	315.0	299.2	309.0	276.7	305.0		
10			337.2	371.5	406.4	335.4	299.3	319.5	260.6	295.0		
11			265.3	396.7	382.4	314.1	301.6	295.1	240.6	320.0		
12			283.8	356.0	385.0	346.6	308.4	321.6	293.8	280.1		
13			283.1	394.2	392.3	337.6	318.1	331.9	245.9	290.0	245.7	
14			362.8	436.8	377.6	328.2	312.9	340.4	269.0	277.9		
15			349.6	414.1	387.0	349.1	314.7	340.5	252.5			
16			354.9	363.0	377.5	376.9	317.4	337.8	261.7			
17			354.5	377.5	356.9	354.7	303.7	325.8	279.4	266.7		
18			352.4	404.0	345.3	361.4	305.2	345.0	271.1	290.0		
19			356.7	332.2	332.2	358.5	302.3	340.7	292.6	275.0		
20			340.0	327.4	342.5	376.8	306.7	336.4	307.0	270.0		
21			416.3	361.1	335.9	397.7	308.6	346.4	316.9	260.0		
22		375.0	426.3	359.3	332.1	384.8	293.9	330.9	349.9	249.3		
23		315.0	448.7	392.0	320.3	371.0	298.2	337.7	358.0	280.0		
24		291.6	426.9	374.2	312.7	343.1	301.0	332.9	371.3			
25		289.7	382.1	360.9		344.9	285.6	332.8	323.1			
26		330.0	354.0	369.4	340.0	350.0	289.9	329.8	295.0			
27		340.0	319.7	377.0	347.8	347.1	304.7	325.0	324.5	267.0		
28		290.0	291.4	398.0	348.5	350.5	316.0	330.0	315.0	223.0		
29			337.7	388.5	350.6	352.9	293.0	321.2	331.4	266.4		
30			406.7	429.1	365.0	353.2	292.8	321.1	298.3	295.7		
31			425.4		358.5		304.7	301.7				

Table C4. *Daily ‘noon’ values of total ozone (DU), Vindeln 2015, Brewer #6.*

2015	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1			325.0	413.0	443.3	369.1	314.3	322.0	303.7	292.1	280.8	
2			390.0	387.5	415.0	398.5	301.5	340.3	293.5	298.2		
3			445.0	392.8	420.3	409.0	276.7	336.6	295.0	275.2	264.7	
4			500.0	392.1	381.3	382.3	325.4	313.3	306.6	286.0	276.4	
5			417.5	389.9	380.0	407.4	311.1	298.4	317.9	304.7	283.1	
6			423.9	340.0	342.7	370.0	301.4	307.5	343.7	268.5		
7			425.0	345.8	363.4	391.7	350.0	298.0	324.8	276.8		
8			359.2	398.6	397.1	380.5	335.9	318.3	298.1	275.1	313.1	
9			401.3	364.4	407.9	343.8	350.0	286.5	291.4	275.5		
10			405.0	361.0	390.5	363.4	339.9	280.8	279.9	268.4		
11		375.4	356.1	373.3	378.6	379.9	331.1	271.5	272.2	256.2		
12		368.6	362.7	381.1	405.5	353.6	330.9	305.0	288.9	282.1		
13		329.1	350.7	420.0	399.2	364.0	332.4	297.5	299.9	300.9		
14			359.4	400.0	395.9	357.0	323.8	282.4	295.9	302.0		
15			352.4	430.7	397.0	394.9	328.0	277.6	292.7	266.6		
16		321.7	348.8	464.2	402.7	378.1	340.1	282.0	302.7	278.3		
17			369.6	436.2	387.6	379.7	341.5	285.0	310.0	264.9		
18		369.2	338.0	384.4	371.4	373.6	318.3	288.7	315.0	245.2		
19		316.4	393.2	365.5	404.2	365.2	348.7	288.4	300.5	263.1		
20		406.1	359.2	360.5	410.0	357.4	338.3	287.4	278.3	281.5		
21		428.0	383.8	377.4	410.4	365.7	336.2	289.4	288.4	355.0		
22		452.3	378.4	404.5	373.1	341.1	336.3	279.5	294.6	290.2		
23		376.8	370.0	434.2	429.0	339.6	341.7	275.7	301.3	309.3		
24		400.4	372.5	435.6	401.0	337.5	337.7	290.2	290.7	275.0		
25		470.0	384.9	399.3	375.0	344.7	338.1	283.4	306.1	310.0		
26		352.0	359.5	425.0	383.2	340.0	335.0	282.1	300.3	308.4		
27		325.0	335.0	403.5	390.0	358.0	338.6	287.6	285.1	283.0		
28		350.0	388.3	431.8	379.7	338.1	314.5	307.8	269.7	234.7		
29			350.0	389.9	357.1	325.6	327.5	299.4	263.7	234.9		
30				452.3	386.6	348.5	340.0	301.1	287.1	230.0		
31					417.2		337.2	307.9		238.4		

Table C5. *Daily 'noon' values of total ozone (DU), Norrköping 2012, Brewer # 128.*

2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	270.3	332.4	370.5	439.8	325.6	425.1	304.7	327.1	317.9	258.0	299.6	323.1
2	294.9	316.4	375.9	494.8	343.4	410.1	326.9	307.2	278.4	273.6	308.9	317.0
3	323.4	320.4	355.9	482.7	350.3	415.8	322.0	318.0	299.9	261.7	308.7	310.0
4	327.6	391.3	357.9	415.5	349.9	407.0	321.3	333.1	260.2	296.0	320.3	274.0
5	321.0	419.3	360.8	394.0	389.1	395.1	314.1	323.7	285.8	297.3	367.8	308.9
6	326.9	419.2	368.8	412.0	392.1	380.1	302.4	322.1	299.2	303.7	348.7	314.2
7	308.5	386.7	394.8	418.5	427.5	355.8	305.7	335.7	305.1	303.8	300.2	321.3
8	344.3	346.7	359.4	400.4	385.8	339.7	322.8	325.5	299.6	295.6	291.0	321.8
9	265.8	363.0	323.7	363.2	373.3	354.2	324.2	333.3	286.2	324.0	272.2	273.2
10	289.1	315.0	350.9	351.7	364.7	363.9	350.0	350.7	277.6	322.0	286.3	280.0
11	311.6	321.7	347.2	391.5	349.2	363.5	343.7	320.6	271.8	335.8	288.0	271.6
12	305.4	309.0	330.8	403.0	380.0	346.5	367.1	310.1	314.4	326.3	300.6	286.3
13	326.6	325.1	339.5	421.2	378.3	356.0	365.6	318.6	332.2	311.7	286.7	306.6
14	294.4	375.9	360.8	421.5	355.9	355.9	346.9	315.4	304.6	309.5	277.0	313.5
15	255.3	391.1	331.0	390.3	362.1	357.2	357.8	308.4	300.2	310.0	298.0	260.7
16	281.3	280.4	326.6	379.3	363.5	373.8	351.2	307.9	277.8	296.7	253.4	283.0
17	289.2	373.5	329.6	451.2	384.0	368.5	357.5	305.6	292.0	296.7	265.7	
18	263.9	345.0	340.9	365.9	341.9	326.8	361.4	287.8	291.4	278.2	289.2	278.9
19	291.6	336.6	480.9	340.2	343.6	334.1	350.6	290.5	313.5	288.8	309.8	271.3
20	337.5	329.3	349.8	382.7	348.9	330.4	359.7	281.8	321.4	290.1	333.2	
21	353.7	293.9	307.3	373.8	350.9	317.2	356.9	284.5	319.1	274.0	294.5	
22	330.9	296.2	298.9	363.6	335.4	305.7	340.6	294.3	316.6	234.4	313.7	
23	308.6	311.9	306.2	371.1	340.2	345.3	303.0	318.8	299.6	234.7	311.1	
24	367.5	294.6	355.9	380.0	329.0	349.4	317.1	298.3	282.9	253.8	334.1	269.1
25	353.6	384.5	328.3	365.6	323.0	375.7	321.9	308.5	289.9	292.1	324.9	
26	321.1	403.4	320.8	365.7	334.5	340.3	321.2	308.3	285.3	315.3	320.5	
27	331.4	371.4	298.1	375.4	335.8	347.6	312.3	316.7	294.3	314.7	330.6	280.4
28	332.9	326.8	335.5	361.5	338.5	**344.3**	310.8	276.1	325.0	300.3	310.6	300.5
29	309.0	344.1	426.7	357.0	408.3	**325.6**	309.2	293.0	278.7	309.0	278.3	
30	297.5		413.2	319.8	382.7	**332.8**	319.5	294.1	287.1	296.0	295.0	285.6
31	312.4		427.8		387.4		354.9	321.0		292.4		

Table C6. *Daily 'noon' values of total ozone (DU), Norrköping 2013, Brewer # 128.*

2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	315.2	421.9	394.3	441.6	398.0	345.7	351.3	340.1	337.0	282.4	309.8	284.5
2	343.7	436.8	368.0	438.3	393.9	343.9	356.5	302.5	335.7	284.7	307.0	267.8
3	315.8	394.2	400.3	416.0	359.0	343.5	335.1	289.7	286.2	278.0	334.1	269.9
4	311.1	372.7	340.9	415.8	391.1	404.7	332.9	311.2	292.3	253.4	339.9	287.3
5	310.7	411.4	350.6	400.3	354.5	355.5	328.5	314.2	282.5	256.4	317.4	306.9
6	325.3	408.1	344.6	407.7	329.8	353.2	322.3	314.2	274.3	240.1	287.0	340.5
7	344.3	425.1	327.4	437.9	344.1	361.6	335.7	307.3	276.0	248.0	274.2	337.7
8	320.0	418.1	360.9	428.2	343.0	371.5	330.5	298.2	293.3	248.8	311.2	301.1
9	351.1	411.6	408.1	421.6	334.1	386.0	323.0	320.3	293.8	270.8	345.1	278.3
10	385.8	410.1	431.4	388.5	377.1	380.7	345.3	320.3	296.3	283.8	338.5	260.4
11	390.8	427.6	419.6	440.8	351.0	361.0	343.1	332.3	297.6	276.8	257.5	232.1
12	377.4	421.1	422.0	388.6	370.5	354.5	341.3	343.7	291.0	280.0	299.6	233.4
13	379.1	433.1	455.9	448.7	375.9	345.2	338.9	347.7	291.8	285.6	319.7	281.5
14	389.1	422.7	445.8	398.3	420.1	360.3	352.0	353.7	299.1	279.4	287.7	295.3
15	402.9	415.7	449.6	366.5	342.1	383.1	346.3	330.9	289.2	275.7	298.5	264.3
16	404.0	399.2	440.7	393.7	352.6	430.1	328.8	320.7	289.9	266.9		286.8
17	431.0	376.6	439.2	378.9	315.6	388.8	323.9	332.3	308.4	270.2		306.7
18	435.0	374.0	441.1	328.1	321.3	361.0	336.9	322.2	324.0	289.3	308.2	304.8
19	417.7	397.3	417.8	423.3	322.9	344.4	362.5	329.9	316.0	275.2	318.8	
20	405.1	405.4	419.1	360.0	316.6	352.7	315.7	332.7	307.7	284.4	314.1	330.8
21	375.9	376.5	428.8	356.7	323.2	322.5	331.8	316.1	291.1	294.6	332.7	286.6
22	354.7	391.7	417.7	409.3	337.8	347.7	340.1	320.6	297.1	265.5	309.5	324.3
23	345.0	399.3	426.7	351.6	390.7	333.8	342.5	324.3	283.5	267.8	315.2	361.9
24	356.2	347.8	414.0	294.9	354.5	348.7	349.3	313.4	330.2	278.5	334.3	306.5
25	367.6	311.1	403.7	330.1	354.1	328.4	351.3	304.7	314.8	282.1	317.2	312.1
26	397.0	308.9	437.5	350.2	352.1	327.7	352.6	300.2	318.0	296.2	314.4	303.8
27	352.9	289.2	407.7	389.4	356.1	334.5	332.1	301.7	308.8	261.2	275.5	295.1
28	371.3	302.5	420.1	335.8	351.2	332.1	317.8	308.3	299.8	272.6	321.0	338.7
29	380.9		408.8	349.8	354.3	373.8	311.2	302.1	275.1	293.4	363.4	334.6
30	393.9		393.8	428.0	357.7	350.1	326.9	306.7	279.2	313.2	313.2	280.1
31	437.0		406.3		370.7		343.8	290.4		278.2		301.0

Table C7. *Daily 'noon' values of total ozone (DU), Norrköping 2014, Brewer # 128.*

2014	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	315.4	329.9	327.9	399.4	390.3	359.8	375.5	338.2	312.4	295.0	250.5	303.0
2	293.8	391.8	350.2	373.8	411.7	349.6	369.3	325.7	298.3	289.7	258.4	293.9
3	321.6	351.6	349.3	379.7	409.8	349.3	338.8	325.4	282.5	289.4	268.3	288.6
4	340.7	360.9	359.5	378.6	404.3	345.2	326.2	334.7	276.2	283.1	297.3	330.0
5	384.8	378.9	350.0	373.9	398.1	365.2	339.0	312.5	284.7	294.9	294.2	358.4
6	286.6	414.0	288.4	383.5	379.9	346.3	329.4	318.7	286.5	312.1	283.5	352.0
7	339.5	405.8	325.8	358.8	408.0	392.5	320.5	332.7	284.6	310.9	262.1	356.1
8	377.5	391.0	326.5	372.9	396.2	329.2	315.4	323.6	290.1	330.7	247.3	357.2
9	401.4	375.1	271.8	378.7	411.9	329.7	317.5	320.2	305.0	287.8	263.1	390.5
10	368.0	368.7	302.8	355.9	384.5	320.8	323.1	328.1	296.9	291.6	275.8	333.8
11	336.1	416.1	281.8	397.6	417.6	316.0	324.7	325.6	272.6	295.8	268.5	349.2
12	362.0	447.9	267.5	343.7	398.9	364.8	327.0	340.7	267.1	314.5	256.9	405.4
13	336.1	457.0	295.4	397.1	401.7	364.7	337.4	356.7	269.7	287.4	272.2	376.9
14	381.5	475.8	334.6	412.5	379.4	347.2	352.0	346.8	261.8	275.6	258.6	289.0
15	368.4	434.6	402.4	421.3	366.9	347.4	340.2	349.0	271.6	281.4	273.7	289.1
16	359.1	485.0	333.3	361.8	350.3	373.9	323.3	354.2	278.1	296.0	274.1	335.0
17	357.9	414.8	315.7	365.4	343.9	361.8	323.4	340.0	277.6	277.9	280.8	297.7
18	366.0	422.9	295.8	460.5	337.9	349.7	332.9	356.2	288.5	273.3	280.0	326.2
19	374.2	418.9	349.5	337.4	340.8	371.8	330.8	351.7	287.4	258.3	301.2	302.3
20	340.2	355.1	320.3	345.7	364.2	379.9	331.3	354.7	279.7	278.2	287.6	288.7
21	356.9	335.7	354.7	381.0	355.0	388.0	333.1	362.4	324.9	257.5	314.1	296.9
22	350.6	376.1	388.7	387.0	341.0	398.4	340.3	349.3	340.9	283.6		267.1
23	320.6	298.5	427.8	374.1	324.0	398.4	325.6	355.5	320.1	277.0		296.7
24	345.1	328.0	436.5	371.4	329.2	373.5	326.0	363.4	330.0	263.7		310.4
25	287.9	324.5	438.5	374.7	341.9	360.7	325.3	368.5	331.4	274.4	293.4	351.1
26	358.3	350.9	403.4	374.6	343.9	359.8	325.2	354.1	285.1	266.3	308.7	329.2
27	318.1	378.1	372.8	378.1	349.4	372.3	330.7	346.4	311.2	248.9	289.3	322.8
28	330.5	329.9	323.6	385.1	347.0	373.0	330.1	345.6	290.5	236.7	279.8	328.6
29	317.2		307.8	359.6	355.3	365.9	315.7	325.8	286.7	258.5	292.8	319.2
30	368.0		366.3	375.8	356.7	371.7	311.9	325.6	289.5	267.0	296.3	299.6
31	384.3		369.1		361.8		322.2	323.1		263.0		259.4

Table C8. *Daily 'noon' values of total ozone (DU), Norrköping 2015, Brewer # 128.*

2015	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	313.2	456.2	318.7	473.2	474.1	387.2	322.7	352.9	291.5	275.2	279.6	391.7
2	364.0	443.3	378.1	447.1	425.3	407.3	309.7	351.6	285.2	270.1	279.6	266.0
3	378.4	446.2	436.3	416.9	387.7	395.5	298.0	326.2	295.8	265.0	292.3	277.1
4	433.2	399.9	455.4	407.6	401.5	391.0	333.6	315.6	308.1	287.0	273.8	292.8
5	308.0	353.3	438.3	392.2	355.3	362.8	322.0	313.4	316.6	296.3	319.2	266.9
6	312.3	321.9	408.3	347.6	353.4	356.3	341.9	319.2	352.6	282.0	328.7	282.0
7	319.0	341.5	364.3	322.7	399.3	383.3	326.8	299.7	325.5	278.3	327.5	269.0
8	344.5	372.7	339.9	309.8	419.3	400.9	374.2	298.3	319.3	296.1	322.3	242.4
9	433.6	321.0	361.0	328.0	392.6	385.7	358.3	294.5	305.1	305.4		280.0
10	335.2	289.6	357.5	338.7	416.1	343.7	363.3	298.5	293.8	274.1		
11	396.8	306.6	392.4	339.7	380.6	338.2	346.7	296.1	304.2	298.1		342.0
12	390.0	367.0	377.7	410.8	372.3	349.5	346.6	309.6	313.8	304.2		357.1
13	420.2	379.5	368.2	440.7	423.6	350.1	348.4	297.4	296.3	297.5		314.0
14	514.8	355.3	374.7	377.0	404.2	363.9	352.2	291.1	289.3	323.2		330.7
15	404.6	354.8	378.8	372.6	419.9	395.2	358.1	290.7	323.1	306.1	345.0	324.2
16	459.3	341.2	398.9	469.0	375.9	387.5	373.8	290.4	303.3	286.8	303.0	288.5
17	480.4	330.5	403.6	457.8	401.4	363.9	344.3	298.0	304.2	273.0	325.8	286.7
18	441.5	336.7	384.9	387.0	422.3	385.5	338.2	305.2	313.0	262.5	289.5	286.2
19	447.9	283.6	413.8	385.0	394.6	383.3	342.6	309.0	314.6	280.0	326.2	245.9
20	425.4	382.6	404.6	364.8	403.0	389.4	365.2	311.8	332.3	289.0	314.6	244.3
21	397.8	405.9	391.6	382.1	435.0	379.8	342.3	312.2	315.2	322.3	373.0	320.9
22	412.0	458.1	333.9	379.7	382.2	386.3	335.0	312.6	301.4		345.5	306.3
23	361.6	397.9	304.6	385.8	412.4	383.2	348.6	312.8	306.3	296.7	308.3	289.4
24	334.0	410.3	335.6	387.1	375.1	369.9	341.8	324.0	301.8	277.5	275.7	283.8
25	410.4	406.2	389.5	370.3	372.1	368.0	325.1	285.8	300.8	302.1	309.6	325.2
26	322.8	342.3	342.8	421.9	384.9	373.3	358.0	304.2	305.0	284.2	275.3	327.9
27	402.2	368.3	349.5	386.9	393.5	347.4	337.0	295.5	303.2	261.4	259.9	256.5
28	347.2	346.9	377.3	397.8	372.8	353.3	361.0	311.0	283.6	270.5	319.3	265.2
29	438.0		379.9	452.3	410.5	351.6	363.0	312.3	272.1	265.7	350.7	254.4
30	448.0		453.1	446.5	419.1	336.2	371.3	305.3	263.5	249.7	399.5	257.6
31	457.3		417.5		424.6		355.8	287.9		233.3		311.9

Table D1 History of intercomparisons, used instrumental constants and major changes of Brewer #6.

DATE	OZONE		SO_2		SL		REFERENCE	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					3665	1897	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 Izaña
1995 Dec													The dispersion was changed back Izaña disp. probably in error
1996 May	no change	no change			3720	1935	Br#017 Norrköping						Br#128 was calibrated, no change of Br#6 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			3685	1915	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
2008 June	2965	.3509	2870	1.1702	3550	1840	Br#017 Vindeln						
2011 Mar 25	2915	.3488	2870	1.1702	3480	1810	Br#185 Sodankylä	0	-0.26	-0.84	-1.9	-3.0	New temp coeff
2013 Jun	2940	.3488	2820	1,1712	3440	1790	Br#017 Vindeln						

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	1.171	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 coeff.
2003 Jun	1700	0.3491	600	1.171	1000	463	Br#017 Norrköping	0	0.1029	.0962	.3465	.2688	New temp coeff
2006 Jun	1687	0.3491	520	1.171	970	450	Br#017 Norrköping						
2009 Jun	1665	0.3491	450	1.171	950	438	Br#017 Norrköping						
2012 Jun	1670	0,3491	505	1,171	960	440	Br#017 Norrköping						These ETCs **not** used. The ETCs of 2009 was used until Aug 2015.
2015 Aug	1670	0.3491	450	1.171	990	446	Br#017 Norrköping						

Table D3 History of intercomparisons and major changes of Dobson #30, since 1990.

DATE	**Remarks**	**Site and Reference**
1990	Completely refurbished	Calibrated at Boulder vs D# 83 World primary standard
1995 24 July – 4 Aug		Calibrated at Arosa vs D# 65 World Sec. standard
2001 10-21 June		Calibrated at MOHp vs D# 64 Regional standard
2007 10-21 June		Calibrated at MOHp vs D# 64 Regional standard
2010 5-16 July	New mirrors and new electronics	Calibrated at MOHp vs D# 64 Regional standard
2016 30 May – 10 June		Planned calibration at MOHp

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