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Weine Josefsson, Mikaell Ottosson Löfvenius

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 2009-2011. Significant incidents affecting the measurements are documented. Daily data are listed and plotted.

This work was supported by the Swedish Environment Protection Agency.

Sammanfattning

Rapporten sammanfattar kvalitetskontrollen, kvalitetssäkringen och mätningarna av totalozon vid Norrköping och Vindeln under perioden 2009-2011. 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 0804 med diariernummer 235-1445-10Mm och 235-1769-08Mm samt specialprojektet 721-5507-10Mm. Motsvaras vid SMHI av följande diarienummer 2010/679/1933 samt 2010/2126/1933.

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1. Introduction

The purpose of this report is to summarize and document the ozone monitoring project for the period 2009-2011. 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 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 there is also a Brewer ozone spectrophotometer #6 Mk II since 1996, but also a Dobson ozone spectrophotometer #30. The latter is the 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.

Brief descriptions of quality control, quality assurance and measurements of total ozone at Norrköping and Vindeln for the years 2009, 2010 and 2011 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 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 are given, see figures in chapter 5, and the daily standard lamp test values, figures in chapter 4. Monthly values of total ozone for all years are presented in Appendix B and daily values for the years 2009-2011 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 via the regional standard Dobson #104 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

Data has been used for validation of satellite algorithms for total ozone. The 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.temis.nl/docs/AD_TOSOMI.pdf

It is notable in this study (Table 1.2) that the number of used data points from our Swedish stations is relatively high, despite the fact that we have problems measuring due to frequent clouds and low solar elevations

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). Interestingly, the results from Vindeln differ significantly from the results of mid-latitude stations. The cause of the difference is not fully understood. This underlines the value of high quality measurements at high latitude sites. Within an EC-financed project SAUNA several Dobsons and Brewers have been together in Sodankylä in northern Finland to get more data to study how well these instruments measure at low solar elevations. This experiment was repeated in early 2011 with the participation of our instruments from Vindeln see Chapter 4.4.

Another example of use of data is illustrated by Loyola et al. (2009). Norrköping and Vindeln total ozone is used along with other long-term series from satellites and models.

In a recent study by van Roozendael et al. (2011) where both Vindeln and Norrköping has been selected from all WOUDC-stations to be included in a study to validate the Ozone ECV (Essential Climate Variables) satellite data products; see http://www.esa-ozone-cci.org/?q=webfm_send/15 e.g. Section 7.11 pp 40-.

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 a spectrally aligned 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.

The lamps used for the Brewers have a life-time of one to two years. The Dobson lamps are not operated as frequent and therefore last longer. In this period the number of remaining spare lamps was low and new ones had to be bought. This was not as easy one would believe. Because, in recent years there has been restrictions regarding mercury as it is toxic. Regarding the halogen lamps they are now provided with UV-protecting glass bulbs and thus they give no UV-irradiance.

There is also a demand that the lamp should fit in the instrument. The size, voltage, output and socket should be correct. Otherwise the lamp-house and maybe the electronics of the instrument has to be altered. However, there were still a lamp of each type available on the market. A number of lamps was bought hopefully sufficient for 10 to 20 years of operation.

4.1 Brewer #128

The latest comparison of Brewer #128 was done at the site in Norrköping in 2009. The change relative the previous comparison in the year 2006 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 comparison in 2006 the R6-value decreased roughly by 12 units up to the comparison of 2009. This roughly corresponds to 2 DU. A smaller decrease has been observed after that.

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. The small change in the standard lamp R6-value indicates that the next comparison in Norrköping in 2012 will only result in a small change.

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

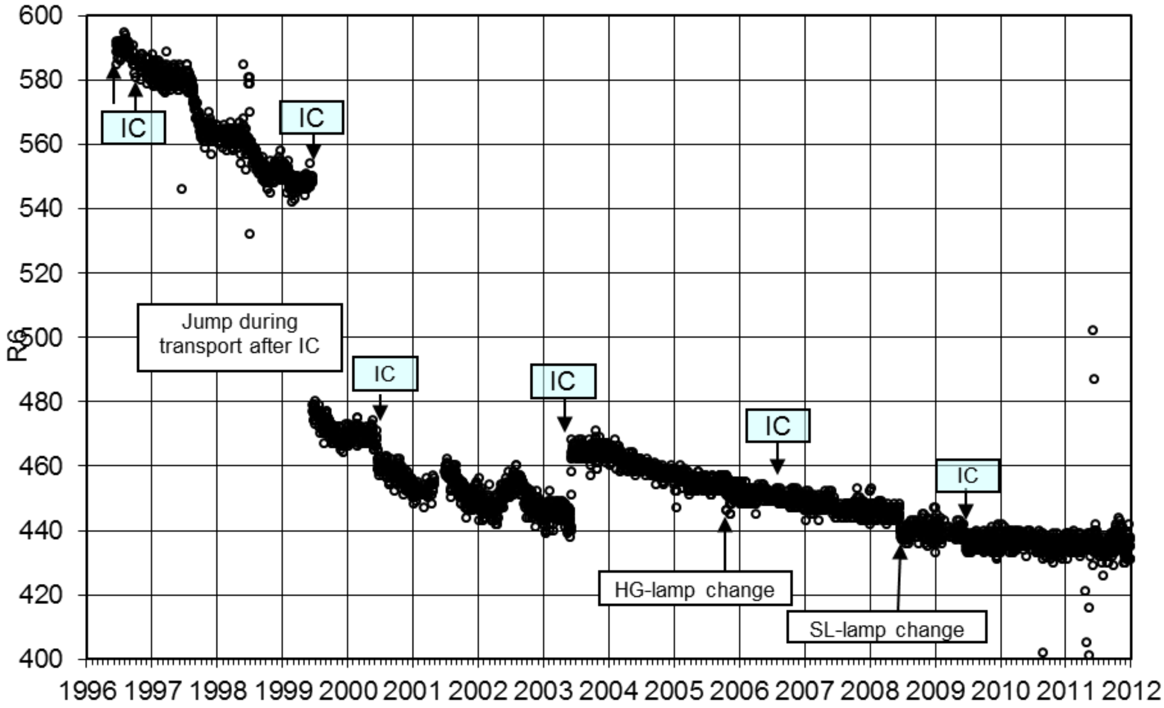

Figure 4.1 Standard lamp test value R6 for Brewer #128 over the period 1996-2011. The large change after the calibration in 1999 is clearly seen. Times for intercomparisons (IC) *are noted as well as some lamp changes.*

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. 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 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 38 ns over the period 1997 to 2008.

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. However, the dead-time continued to decrease after 2008 and it is now about 37 ns.

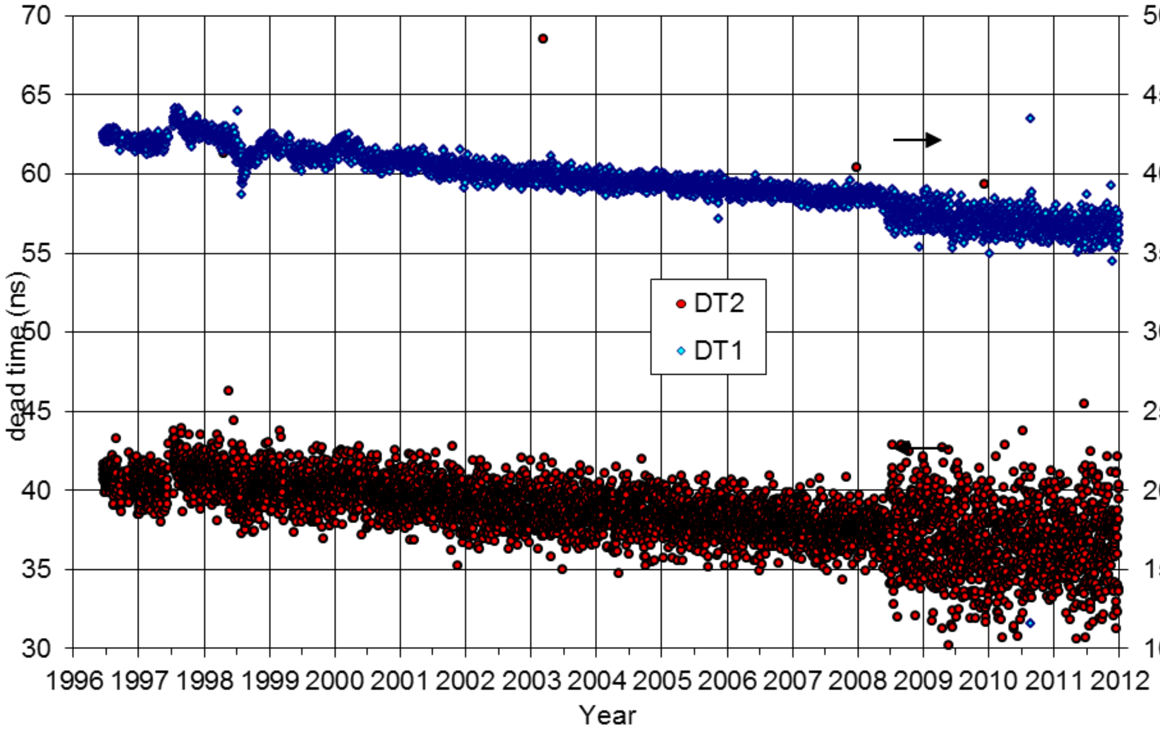

Figure 4.2. Dead-time (ns) *for Brewer #128 for the period mid-1996 to 2011. The scatter increased in 2008 when a weaker lamp was introduced.*

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 rapid 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.

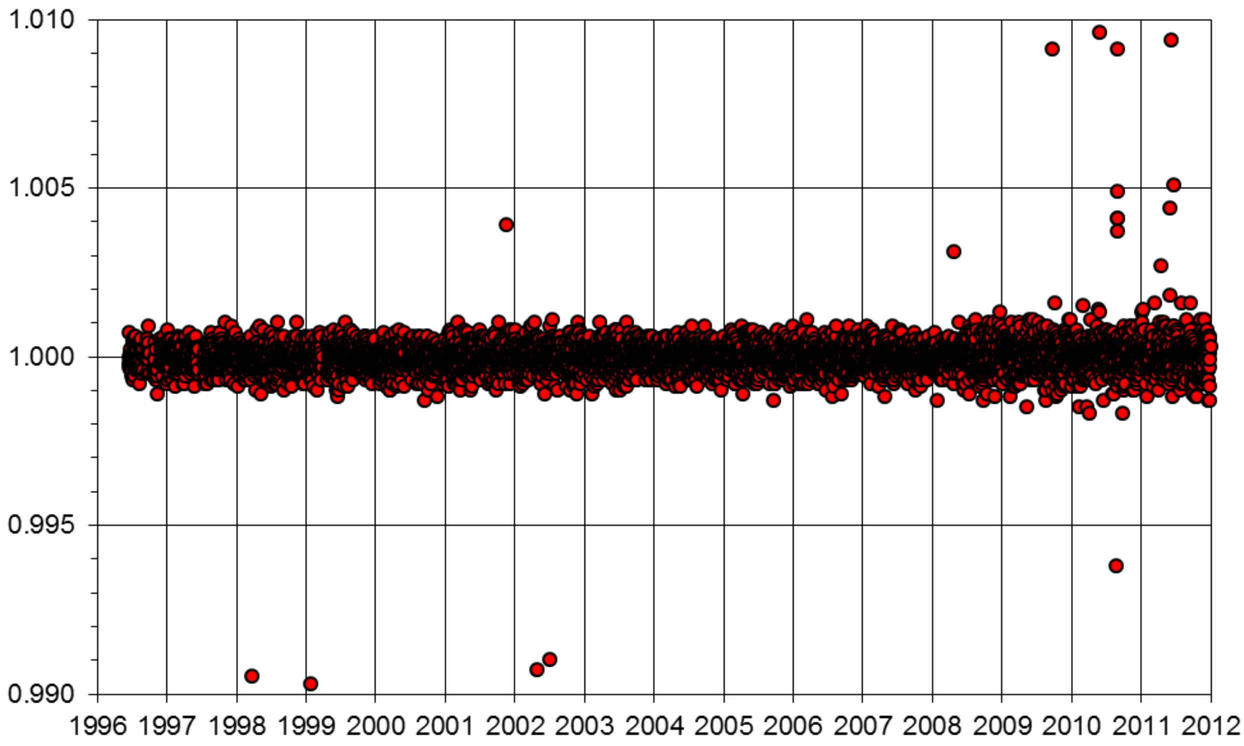

Figure 4.3. Run and stop test for Brewer #128 for the double slit position of the shutter mask for the period 1996-2011. A slight increase in the scatter and also in the number of outliers can be noticed from mid-2008

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 before most tests are performed on a daily basis and at longer time intervals comparisons and service are done. 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.

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 resulted in small shifts in the R6-value. At the last 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.

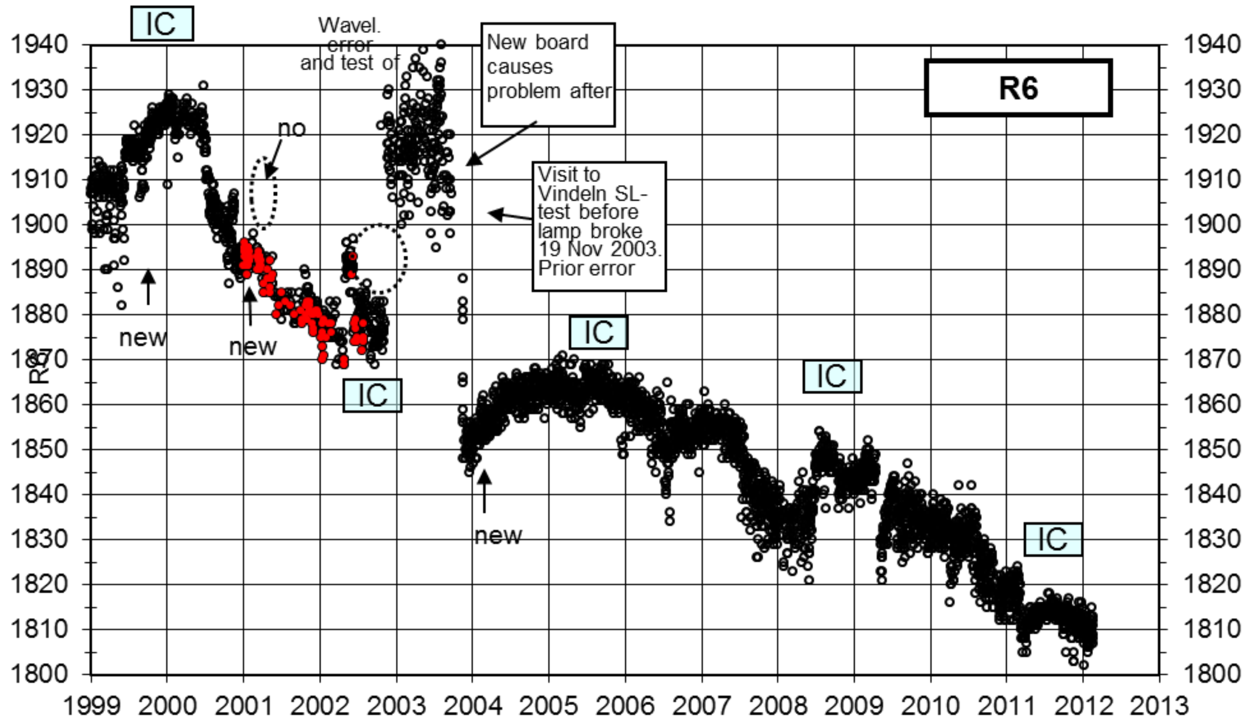

Figure 4.4. Standard lamp test value R6 for Brewer #6 over the period 1999-2011. Comparisons (IC) *and lamp changes are noted as well as comments to some outliers.*

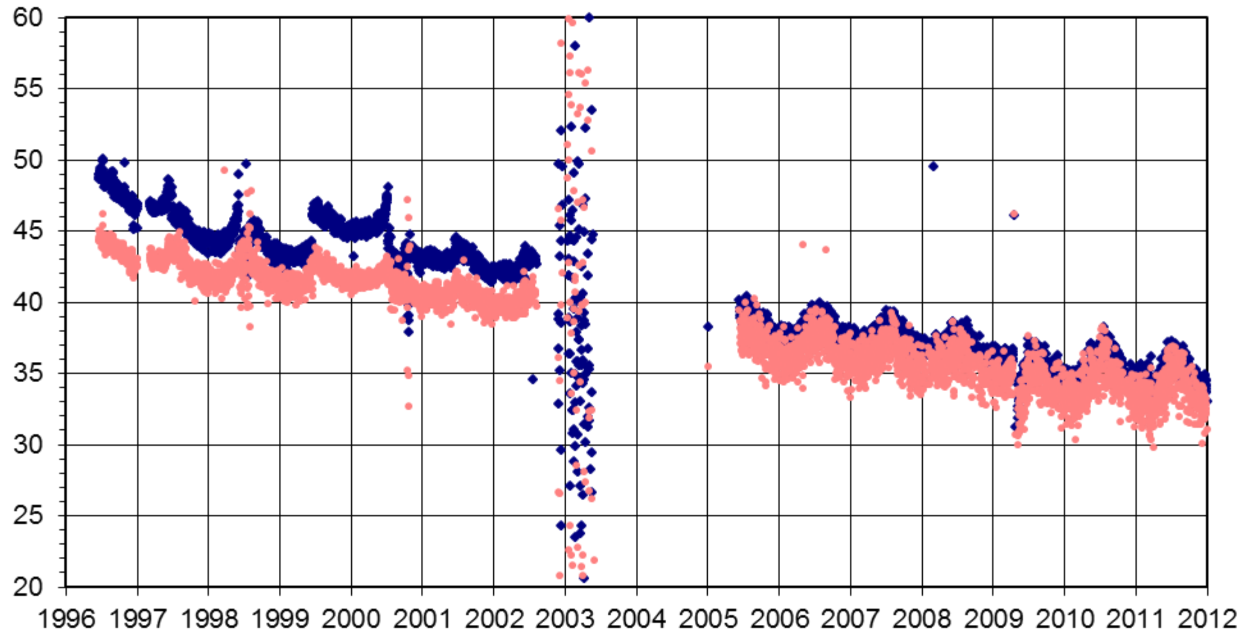

Figure 4.5. Dead-time (ns) for Brewer#6 for the period 1996-2011.The two colors are for a low and a high intensity respectively.

The dead-time of the Brewer #6 has decreased over the period 1996 to 2012, Figure 4.5. There has also been a clear yearly cycle. This is probably due to a 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.

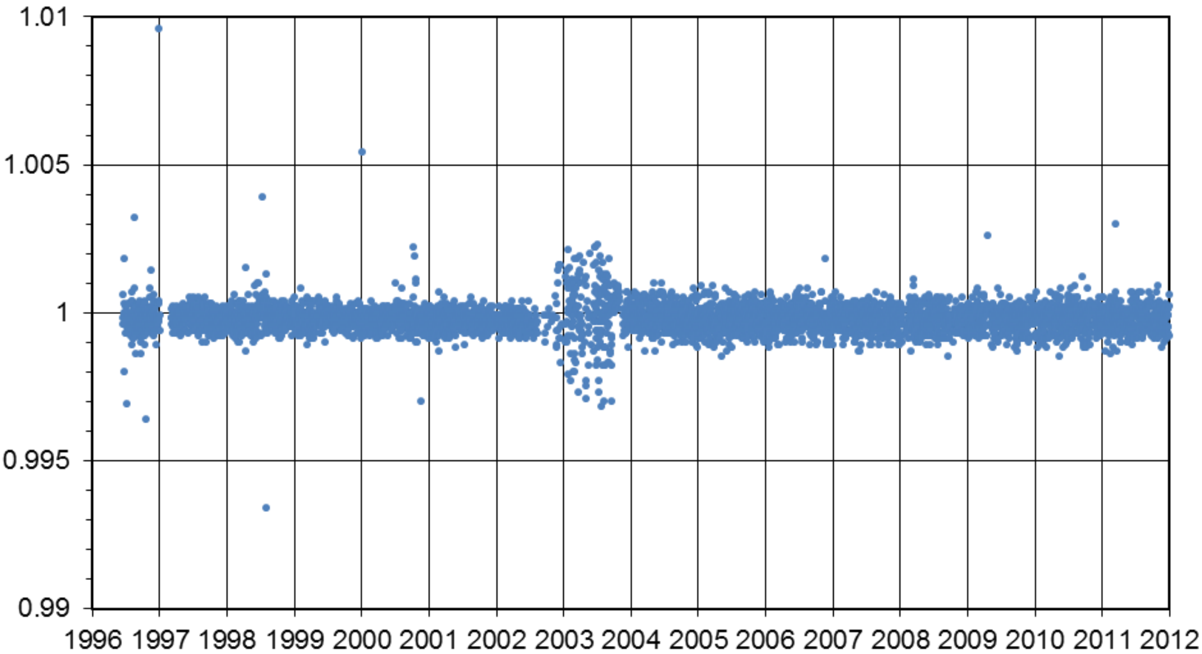

Figure 4.6. Run and stop test for Brewer #6 for the double slit position of the shutter mask for the period 1996-2011. Note the problems in 2003.

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. This caused a larger scatter in the data.

4.3 Dobson #30

The Dobson #30 was sent in mid-June 2010 to Hohenpeissenberg, Germany, for a major refurbishment and upgrading. The mirrors were replaced, which means that the instrument 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 with 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 are delivered to WOUDC. Lamp calibrations are made once a month. The lamp 30Q1 is used every month. The lamp 30Q2 was used twice a year until it broke down in June 2010 and was replaced by the lamp 30Q4. The lamp 30Q5 is used 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 in 2009. The more sensitive wavelength pair C’ is not used for standard observation and has not been calibrated since Arosa 1996.

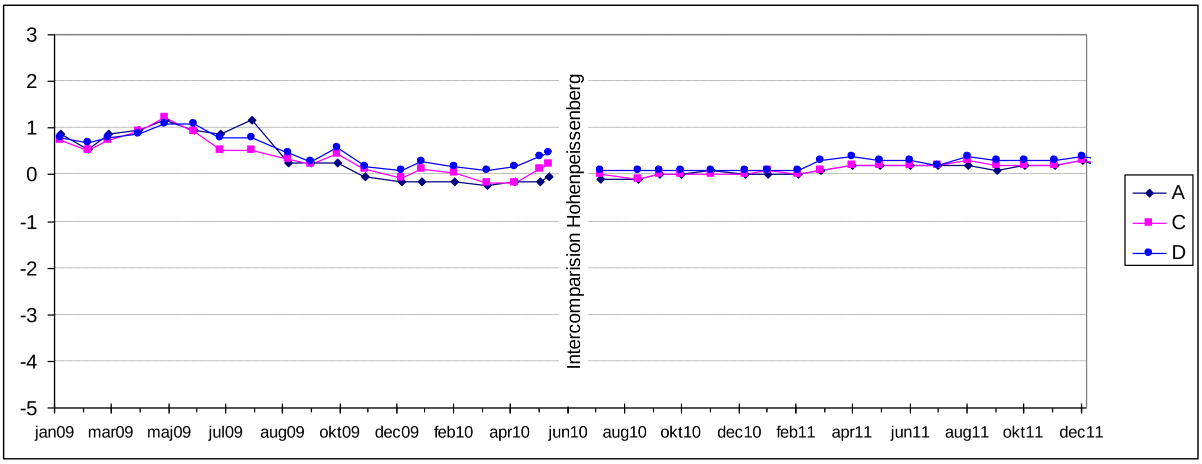

Figure 4.7.Correction coefficients based on the Dobson standard lamp tests (30Q1) for the period Jan 2009- December 2011. The various lines denoted by letters A, C and D refer to the used wavelength pairs. Wavelength pairs of C’ are not used for standard observations.

4.4 Dobson #30 and Brewer #6 at CEOS

In a special project, supported by NV and ESA-CEOS, both Brewer #6 and Dobson #30 participated. The main goal was to study the characteristics of the instruments at low solar elevations and low temperatures.

Other topics were the influence from small differences in the algorithms of Dobsons and Brewers respectively. For example in the algorithm the optical path through the ozone called the µ-value is computed assuming an average height to the layer of ozone. This height differs in the Dobson and the Brewer algorithm. At high solar elevation the difference causes negligible effects. But, for a low sun it is not. On basis of the manifold of simultaneous measurements at various solar angles with the Dobsons #64 and #30, the effect of altering the mean height of the ozone layer and applying temperature correction were analyzed.

During the visit to Sodankylä a diary was updated daily on the web.
https://sites.google.com/site/saunacampaign/home
here it is possible to follow what happened during the campaign. The scientific results will be available at the following site, where older CEOS-reports also are available.
http://uv-vis.aeronomie.be/projects/ESA_CEOS/ESA_CEOS_Deliverables.php

A few results regarding the status of our instruments will be presented and discussed here. In order to prevent the photomultiplier of the Brewer instrument to be saturated there are so called neutral density filters. In the algorithm they are assumed to be spectrally neutral, i.e. the irradiance of all wavelengths used for the ozone computation are reduced in the same way. This is not exactly true. As can be seen in Figure 4.8 there is a wavelength dependence. It is not large, only fractions of a percent.

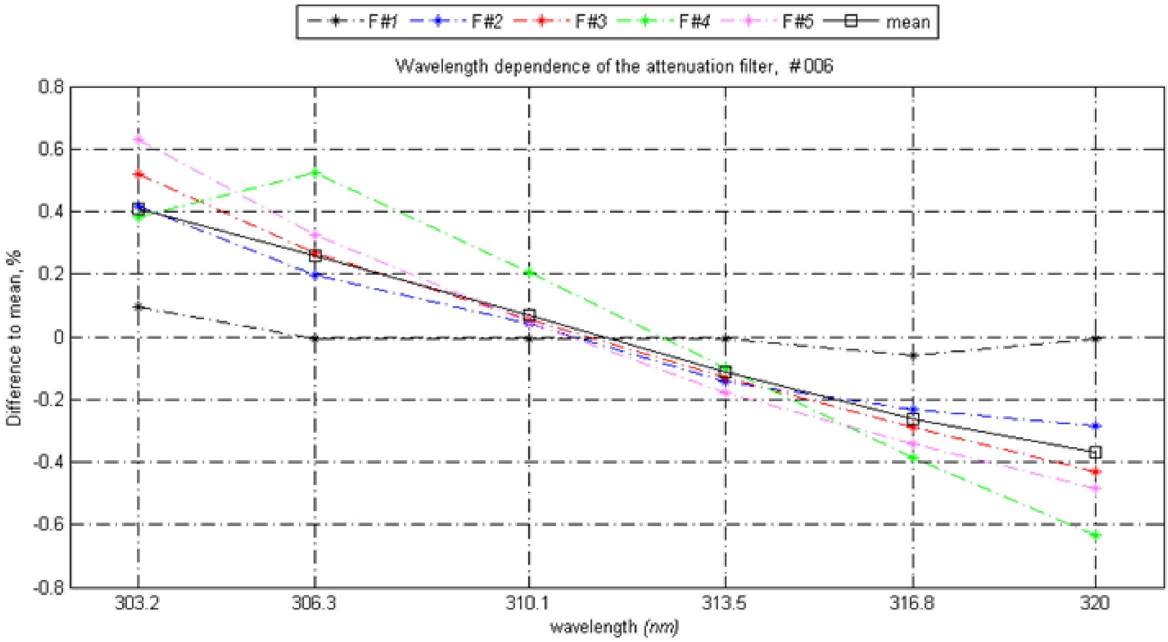

Figure 4.8 Wavelength dependence of the neutral density (attenuation) filters of Brewer #6 measured for the standard slits of the instrument.

If all filters have the same wavelength dependence and if there is always a filter used measuring the total ozone the effect would be negligible on the final result. This is almost the case for some of the Brewer #6 filters. But, filter #1 and also to some extent #4 deviates from the overall pattern. For the ozone observation it is mainly the four longest wavelengths that are used.

It has not yet been estimated how large effect there is on the actual values of total ozone.

Another valuable result from the campaign was that new temperature correction coefficients were produced. The use of the new ones also changes the standard lamp reference values R5 and R6, see Figure 4.9. This will cause an artificial jump in e.g. the R6-value, which is tracked over time to see eventual changes in the instrument in-between comparisons.

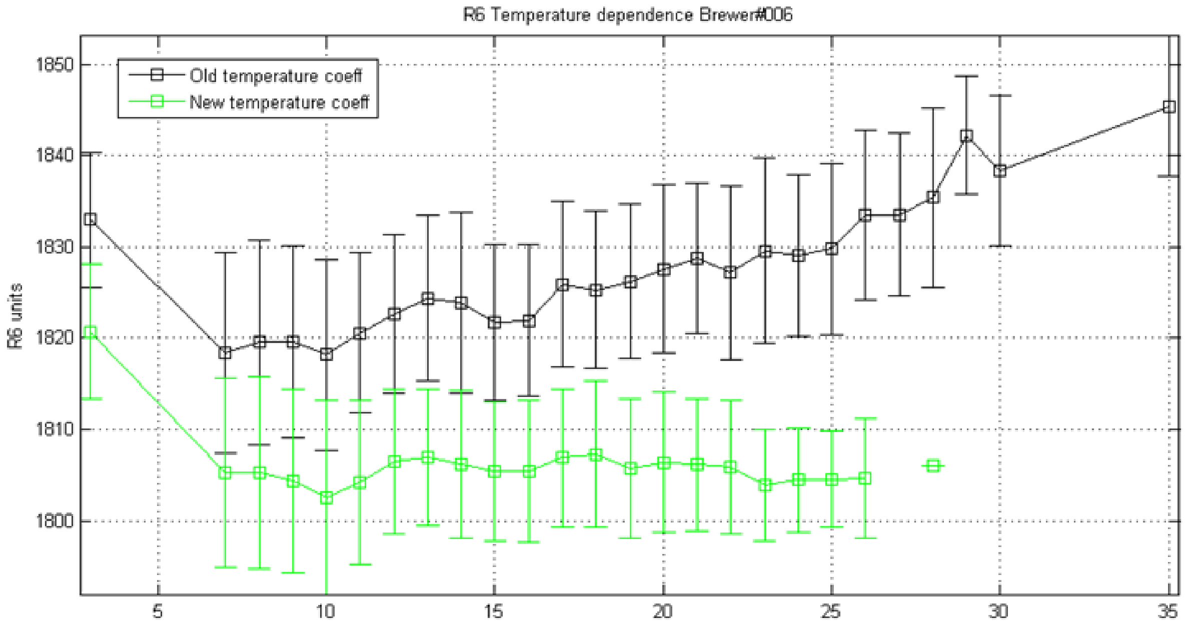

Figure 4.9 Applying the old and the new temperature coefficients for Brewer #6 and plot the R6-value versus temperature shows the improvement, i.e. more stable R6. But it also shows the shift of about 10 units in R6. The disagreement in the level of R6 (roughly 1813 instead of 1805) with Figure 4.4 is due to the change in the extraterrestrial constant used after the CEOS-campaign.

A strange thing regarding the Brewer #6 that was noted during the campaign was that the first standard lamp observation taken early in the morning seems to be off. Something seems to give a significant lower measured value. Instead of having well over one million counts at 320 nm measuring the standard lamp there is less. Roughly a difference in ten percent. It is repeated every morning for the first lamp run. It has not yet been understood why this happens.

The campaign invited to check-up the Dobson #30 calibration since the last intercomparision in Hohenpeissenberg 2010. The result of the campaign showed that the Dobson #30 was in perfect shape. Also, it was found that #30 is well suited for measure at low solar elevations using direct focus sun method, since the r-dial is adjusted in favor for readings at higher values.

5. Observations

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.

Over the period 2009-2011 the total ozone has varied a lot, which is normal at higher latitudes. The years of 2009 and 2010 showed mostly values around the long-term average from Uppsala. Could this be interpreted as a sign of a recovery of the ozone layer? Probably not, because Sweden is relatively small and the ozone varies on a large global scale.

A few episodes are worth mentioning. The first months of 2009 started with relatively thick ozone layer. But in April and early May there was a substantial reduction. At this time of the year the solar elevation is high enough to give a high UV (ultraviolet) radiation in northern Europe.

The next thin ozone layer episode occurred at the end of June and first days of July. This is the time with the highest solar elevations around noon. So this gave high UV-index values. The rest of the Summer and the Autumn as well was around the average. But, December had record high values of total ozone in Norrköping and at the same time very low values in Vindeln.

The next year 2010 started with normal total ozone in but in the last part of February the values rose above 500 DU both in Norrköping and Vindeln. Then the values were mostly around average with the exception of a period in July with slightly thinner ozone. Most interesting of that year was the two last months. Both November and December gave new record high values at both sites. So the record from 2009 only lasted one year. At Norrköping also the yearly value was the highest recorded since the start in 1988.

In the beginning of 2011 the total ozone was varying around the average. But, in the stratosphere over the Arctic the so called polar vortex was the most long lasting for many years. In Spring the ozone depletion can be substantial within the vortex. Most winters in the northern hemisphere the polar vortex disappears in January or February and thus has only a minor influence on the ozone. But in 2011 the vortex formed like a banana rotated over Greenland, Svalbard and the Polar Sea. In late March it moved in over Scandinavia for a number of days. This gave a dip in the total ozone measured as can be seen in the data, see Figures 5.3 and 5.6. The following week the vortex moved to Russia and disappeared. The unusually large ozone depletion was addressed in an article in Nature, Manney et al. (2011).

Also interesting was that the ozone that was photo-chemically destroyed in the stratosphere during this period caused a deficit at high latitudes in the northern hemisphere that could be seen still in the Summer. A more general recovery lasted until the Autumn of 2011.

In a special UV-project the total ozone series has been 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 (-0.03% per year). But, the trends are very small and they are not significant.

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.

Table 5.1 Linear trends (%/year) for each month and for the year of total ozone at Norrköping 1983-2011. The observations starting in 1988 has been extended backwards to 1983 using TOMS-data. Tested for 95% significance. The last column give the number to be exceeded to be significant on this level.

Month	Trend (% per year)	Significance @95%
January	-0.02	0.38
February	+0.15	0.37
March	+0.02	0.32
April	-0.17	0.27
May	-0.05	0.18
June	-0.05	0.18
July	-0.11	0.12
August	-0.06	0.16
September	-0.10	0.16
October	-0.04	0.19
November	+0.13	0.18
December	-0.05	0.33
Year	-0.03	0.14

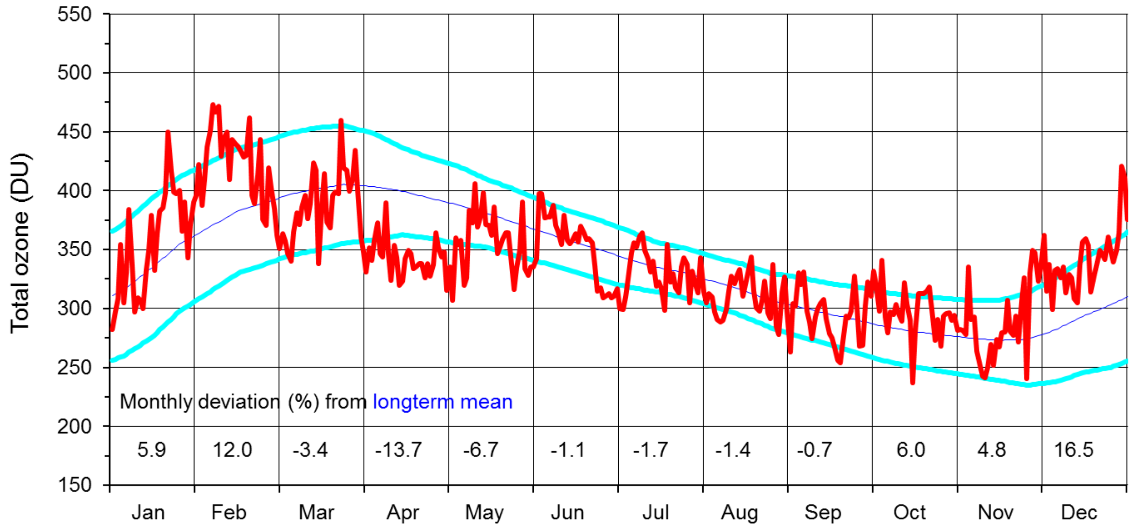

Figure 5.1 Daily 'noon' values of total ozone (red) recorded by Brewer #128 at Norrköping in 2009. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale.

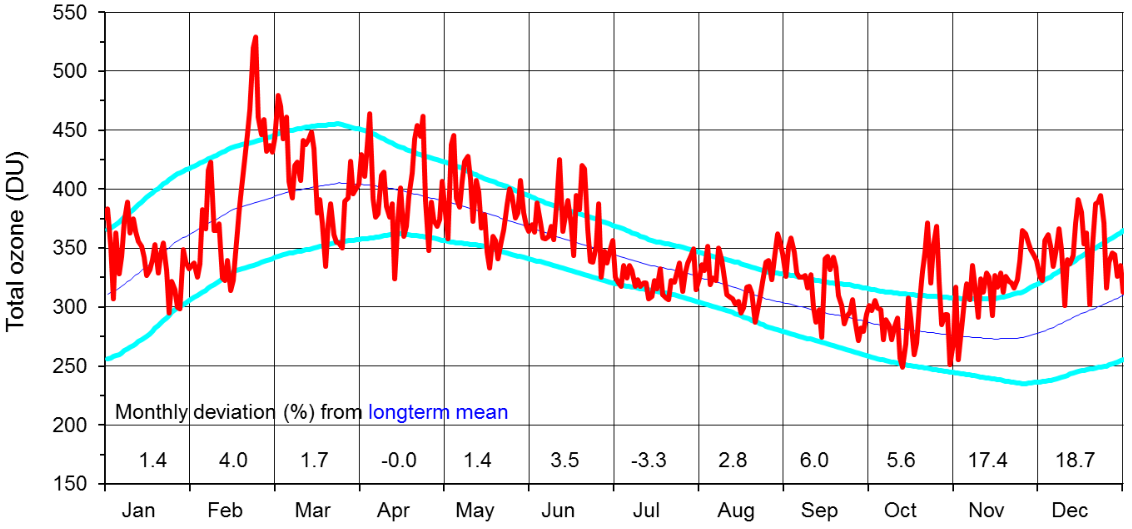

Figure 5.2 Daily 'noon' values of total ozone (red) recorded by Brewer #128 at Norrköping in 2010. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple).

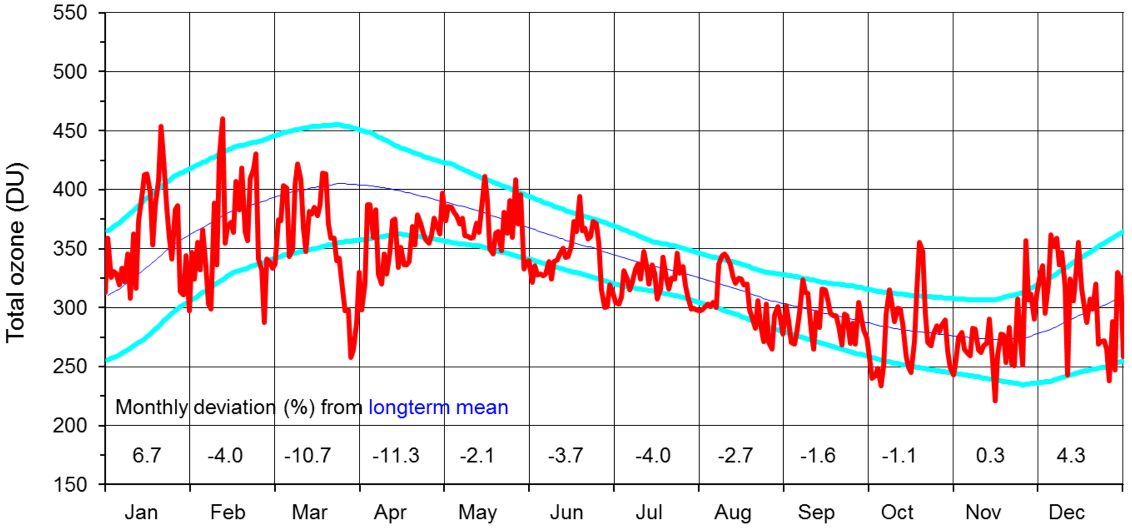

Figure 5.3 Daily 'noon' values (red) of total ozone recorded by Brewer #128 at Norrköping in 2011. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale.

Figure 5.4 Daily 'noon' values of total ozone recorded by Brewer #6 (red) and by Dobson #30 (green) at Vindeln in 2009. 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).

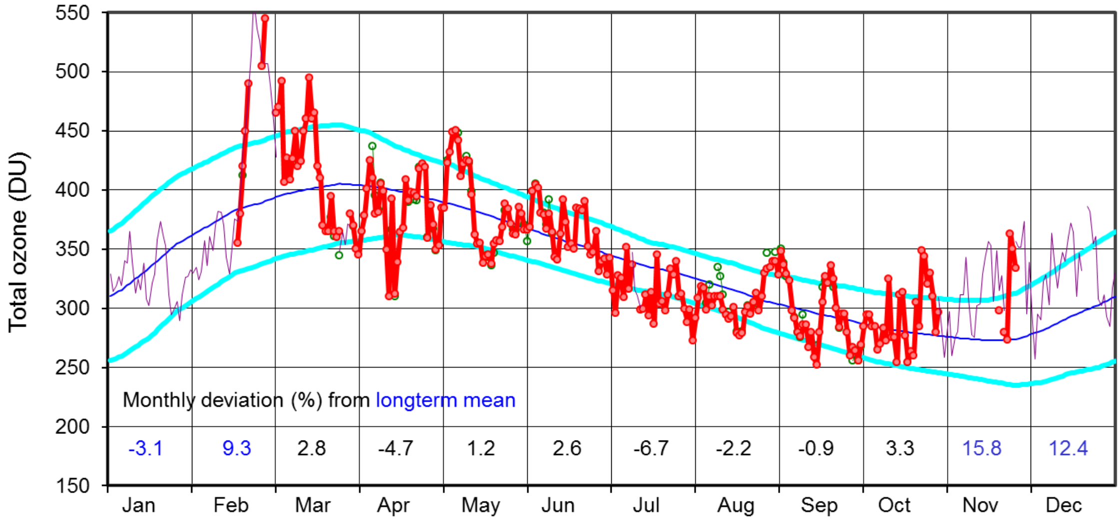

Figure 5.5 Daily 'noon' values of total ozone recorded by Brewer #6 (red) and by Dobson #30 (green) at Vindeln in 2010. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple line).

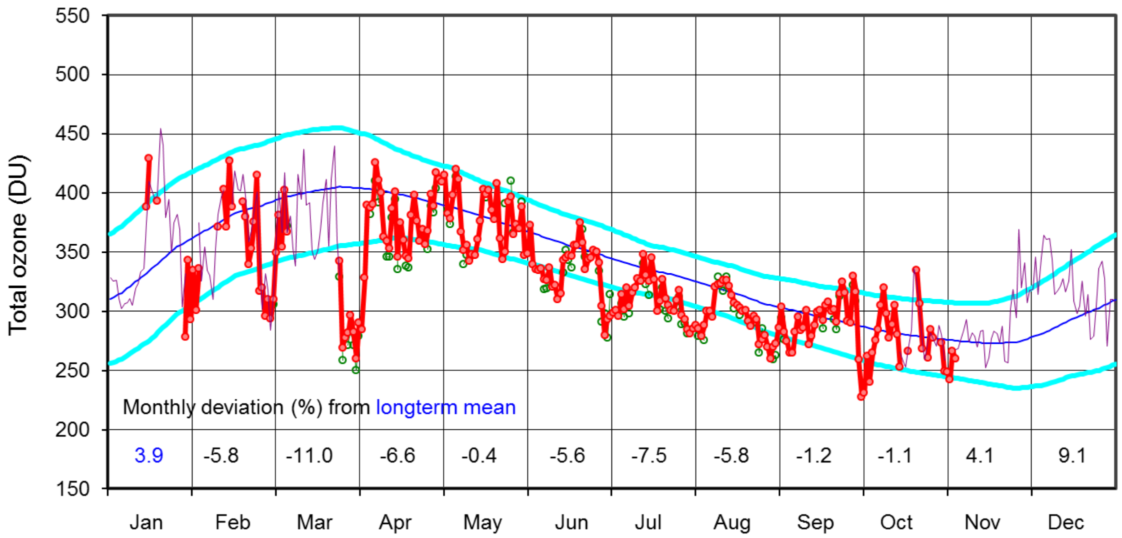

Figure 5.6 Daily 'noon' values of total ozone recorded by Brewer #6 (red) and by Dobson #30 (green) at Vindeln in 2011. Long-term mean and standard deviation are from Uppsala 1951-1966. The values at the bottom are the monthly deviations (percent) from the long term monthly means. All data refer to Bass-Paur scale. Missing data are replaced by satellite data (purple line).

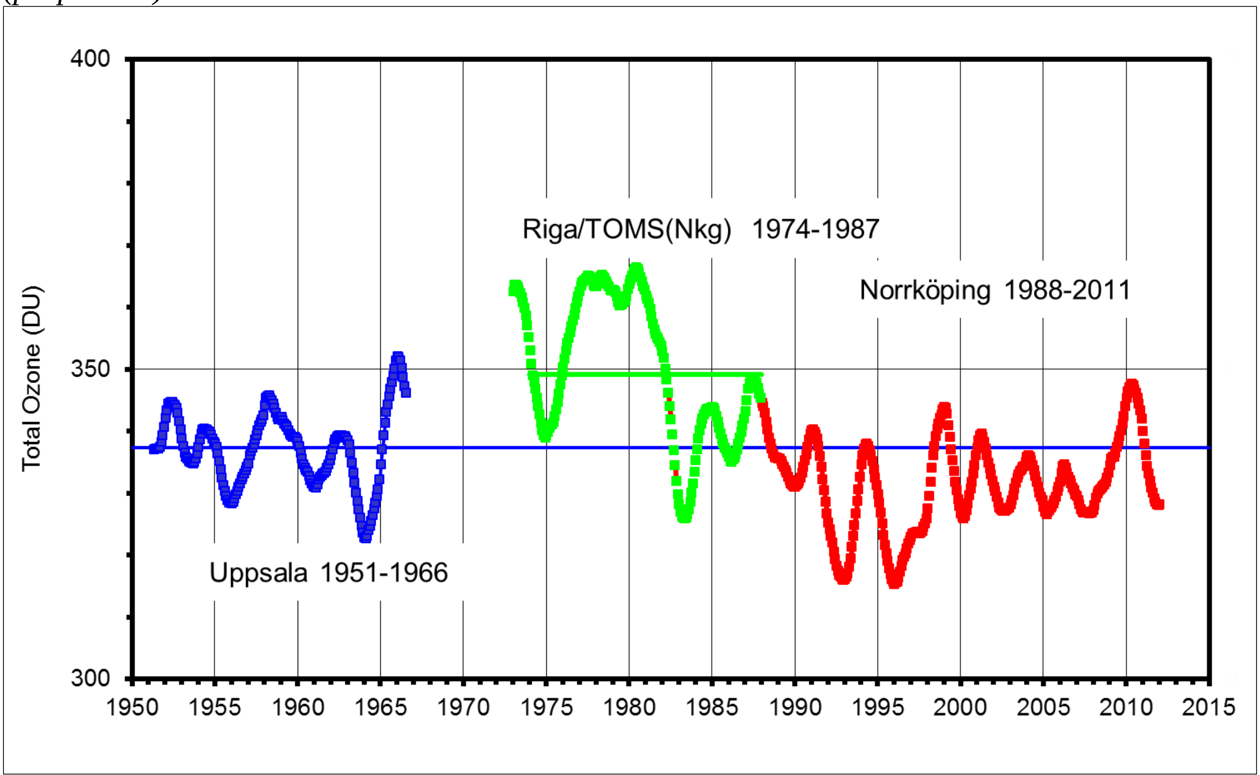

Figure 5.7 The long-term variations of the total ozone in Uppsala 1951-1966 (blue), Riga+TOMS 1974-1987 (green) and Norrköping 1988-2011 (red). The smoothed lines are based on monthly mean values that have been filtered by a two-year triangular filter. The blue horizontal line is the average from Uppsala.

6. Conclusions

The monitoring of total ozone at Vindeln and Norrköping have produced the expected amount of data. Despite some problems the monitoring delivers daily data for the time of year when the solar elevation is not too low. The daily data are stored and they are available at “Datavärdskap” at www.smhi.se and also at the WOUDC (World Ozone and Ultraviolet Data Centre).

As was shown in Table 5.1 there are no significant trends in the total ozone over the period 1983 to 2011 observed 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 in the 1990-ties. Some of the lowest values observed in the 1990-ties were connected to the volcanic eruption of Pinatubo. The effect of Pinatubo lasted for a couple of years. Then the global total ozone seems to have stabilized and we now expect a recovery. This because the ozone depleting substances have been banned according to the Montreal protocol and their concentrations in the atmosphere have decreased and thus we expect to an effect on the total ozone.

However, the process is slow and the natural variation is large and therefore we cannot expect to see an immediate response in the stratospheric ozone. So we have to be patient before we can observe, with significance, the expected recovery.

7. References

Josefsson W., 1988, Mätning av totalozon, SMHI Meteorologi, No.43, December 1988.

Josefsson W., 1990, Measurements of Total Ozone 1989, SMHI Meteorologi, No.16, March 1990.

Josefsson W., 1991, Measurements of Total Ozone 1990, PMK-rapport, SNV, 91-620-3944-x, 1991/06.

Josefsson W., 1992, Measurements of Total Ozone 1991, PMK-rapport, SNV, Solna, 91-620-4093-6, 1992/10.

Josefsson W., 1993, Measurements of Total Ozone 1992, PMK-rapport, SNV, Solna, 1993/10.

Josefsson W., 1996, Measurements of total ozone, National Environmental Monitoring 1993/94, Swedish Environment Protection Agency, ISBN 91-620-4405-2, Stockholm 1996/01.

Josefsson W. and J-E. Karlsson, 1997, Measurements of total ozone 1994-1996, SMHI Reports Meteorology and Climatology, RMK No.79, Sep 1997, ISSN 0347-2116.

Josefsson W., 2000, Measurements of total ozone 1997-1999, SMHI Reports Meteorology and Climatology, RMK No.91, Sep 2000, ISSN 0347-2116.

Josefsson W., 2003, Measurements of total ozone 2000-2002. http://www.smhi.se/polopoly_fs/1.15084!sakrapport-2000-2002.pdf

Josefsson W., 2003, Measurements of total ozone 2003-2005. http://www.smhi.se/polopoly_fs/1.15083!sakrapport-2003-2005.pdf

Josefsson, W. and Ottosson Löfvenius, M. 2008. Total ozone from zenith radiance measurements - an empirical model approach. SMHI Reports Meteorology, No 130, ISSN 0283-7730. http://www.smhi.se/polopoly_fs/1.1735!meteorologi_130%5B1%5D.pdf

Josefsson, W. and Ottosson Löfvenius, M., 2009. Measurements of total ozone 2006-2008. SMHI Reports Meteorology, No 136, ISSN 0283-7730. http://www.smhi.se/polopoly_fs/1.15082!Sakrapport-2006-2008c.pdf

Loyola, D. G. , Coldewey-Egbers, R. M. , Dameris, M. , Garny, H. , Stenke, A. , Van Roozendael, M., Lerot, C., Balis, D. and Koukouli, M., 2009. Global long-term monitoring of the ozone layer - a prerequisite for predictions, International Journal of Remote Sensing, 30: 15, 4295 — 4318. http://atmos.caf.dlr.de/gome/docs/loyola_09.pdf

Manney Gloria L., Michelle L. Santee, Markus Rex, Nathaniel J. Livesey, Michael C. Pitts, Pepijn Veefkind, Eric R. Nash, Ingo Wohltmann, Ralph Lehmann, Lucien Froidevaux, Lamont R. Poole, Mark R. Schoeberl, David P. Haffner, Jonathan Davies, Valery Dorokhov, Hartwig Gernandt, Bryan Johnson, Rigel Kivi, Esko Kyrö, Niels Larsen, Pieternel F. Levelt, Alexander Makshtas, C. Thomas McElroy, Hideaki Nakajima, Maria Concepción Parrondo, David W. Tarasick, Peter von der Gathen, Kaley A. Walker, Nikita S. Zinoviev. Unprecedented Arctic ozone loss in 2011. *Nature*, 2011; DOI: 10.1038/nature10556

van Roozendael M., Koukouli M., Laeng A., Lambert J-C., Loyola D., Stieler G., Tamminen J., van der A R., Weber M. 2011, Data Access Requirement Document (DARD) Issue: 1.2 – Date of issue: 31/05/2011 Reference: Ozone_cci_DARD_1.2 http://www.esa-ozone-cci.org/?q=webfm_send/15 e.g.

Staehelin, J., J. Kerr, R. Evans and K. Vanicek, (2003), Comparison Of Total Ozone Measurements of Dobson and Brewer Spectrophotometers and Recommended Transfer Functions, WMO TD No. 1147, World Meteorological Organization, Global Atmosphere Watch, No. 149, ftp://ftp.wmo.int/Documents/PublicWeb/arep/gaw/gaw149.pdf http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html

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 2009-2011

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.

2009-06-15—18 Calibration and service. Reference Brewer #17. New mercury lamp and new extraterrestrial constants.
2009-10-04 The Brewer clock speeds giving error in time - Disconnected internal clock. Checked for loose cables and made a complete reset.
2009-12-04 Small correction in siting
2009-12-12 Polar kit on
2010-04-02 siting OK. Polar kit off.
2010-06-20 Brewer stopped 18 June due to division by zero in program. Siting was checked and found OK.
2010-06-21—22 problems with the clock – seems OK after reset.
2010-06-23 desiccant big box exchanged and cleaned big wheel
2010-07-17 Brewer stopped due to division by zero in program.
2010-07-18 Changed date and time. Brewer and PC power off and then restart and reset @ 9.20 UTC.
2010-07-25 Brewer stopped due to division by zero in program.
2010-07-26 Brewer stopped due to division by zero in program.
2010-07-29 Restart at 6.40 UTC
2010-07-30 Brewer stopped and restarted at 5.40 UTC
2010-07-30 Brewer stopped again due to division by zero in program – started looking for the problem.
2010-07-31 Changed in program to check if airmass value (μ) less than 0.3 then μ=0.3. Restart at 6.40 UTC.
2010-08-21 Time error of about one hour (?). Corrected at 13.35 UTC
2010-08-25 Dead time (DT), run and stop (RS) test, spurious values and also some standard lamp (SL) tests indicate that something is wrong.
2010-08-29 Problems with the spectrometer alignment at 9.40 UTC. Restart at 11.30 UTC.
2010-08-30 Brewer off and brought indoors at 10.10 UTC. After noting more problems with the RS, DT and SL-tests. Tried all cards in and out to see if there is a problem with bad connections. After adaption to indoor temperature the desiccant was exchanged in the PMT (photomultiplier tube). Reset and tried HG HP SL DT RS tests.
2010-08-31 Brewer out at 12 UTC everything seems OK. But a few days later same problems returned.
2010-09-06 changed standard lamp Brewer in at 7.30 and out at 8.10 UTC. Severe problems with DT, RS and SL-tests. Contacted Ken Lamb and Martin Stanek.
2010-09-07 Ken suggested to check the positioning of the standard lamp. First problem was that the recently bought standard lamps were UV-protected. Thus only a weak signal. Putting back the last of the old type and trimming the pins to get it focused everything started to work as it should.
2010-09-08 Brewer out at 6.30 after a night running tests that were OK. Desiccants were also exchanged 7 Sept. Siting OK.
2010-11-03 Brewer indoors at 14.30 UTC for checking different standard lamps. All of them were UV.-protected and thus couldn't be used. Started to look for a type that works.
2010-11-04 Brewer out at 8.00 UTC.
2010-11-20 Polar kit on at 7.30 UTC
2011-02-17—18 Brewer stopped at mid-night when trying an Azimuth zero after moon measurement. Stop in measurements on the 18 of February.
2011-04-10 Polar kit off at 9.25 UTC. Checked siting found OK.
2011-06-04 The SL-test values didn't look OK. Opened Brewer and changed to the new type of standard lamp. Also exchanged the desiccant in the big box and cleaned the big wheel of the tracker. In the bright sun it was hard to see if the standard lamp was focused. Tested RE, HG and SL. The Brewer stopped when doing the SL. After lunch adjusted the pins of the lamp and made the tests once again. Now it worked. Only noted that the new lamp type seems to be weaker than the old one.
2011-06-28 Restart the Brewer had stopped during Reset at mid-night. The new lamp installation seemed not to be perfect. New problems with the SL-test. Replaced the lamp with a new one at 8.10 UTC. Looked OK and Brewer out at 10.30 UTC.
2011-06-29 Problems with the clock. The time was about 20 minutes off.
2011-06-30 Brewer stopped during reset at mid-night. The clock jumps strangely.
2011-07-01 Brewer in-doors. Contacted ken Lamb and Martin Stanek.

2011-07-02 Answer at 17 UTC Ken suggested to check the 4 output voltages from the main power supply at test points between the SPS board and card rack when the SL is on and off. He suspected that the main power supply was failing, when it tries to deliver the extra current to the SL.
2011-07-03 Measured as Ken suggested and found that the power supply had problems. Had a spare power supply. Exchanged and started to run tests. Everything now seemed OK. Could even measure the sun through an opened window to get some ozone data.
2011-07-04 Brewer was put out-doors after change of power supply and change of desiccant in the big box. As it was humid the other ones were not opened.
2011-11-10 At 8.30 changed the desiccant in the big box.

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

2009-04-24—05-08 Problems causing stop in Brewer #6. Tried to solve from distance failed. Weine J went to Vindeln and opened the Brewer and tested various alternatives. It turned out to be due to bad connection in electronic board for the iris and the filter wheels #1 and #2.

2010-03-26 Weak signal probably snow on the entrance optics.

2010-06-11—07-18 Dobson sent to Meteorological Observatory at Hohenpeissenberg for refurbishment and calibration including upgrade of electronics and mirrors. More details can be found at
https://sites.google.com/site/dobsonozonecalibration/

2010-07-10—11 Brewer stop maybe due to power-break caused by lightning

2010-10-30 Problem occurred when the mercury (HG) lamp couldn't be detected. Hard to say the cause at distance. Luckily the measuring season is almost over at Vindeln.
2010-11-18 brewer in-doors and HG-lamp changed as well as desiccants. Brewer out.

2011-03-07 – 24 Brewer #6 and Dobson #30 participates in CEOS campaign. Thus no data from Vindeln.
2011-03-25 Brewer #6 new calibration at restart.
2011-10-15—16 Brewer stop probably due to problems with focused moon measurements.

Appendix B.

Monthly values of total ozone (DU) for the whole period at Vindeln (1991-2011) and at Norrköping (1988-2011).

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*

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

Appendix C.

Table C1. *Daily values of total ozone (DU), Vindeln 2009, Brewer #6*

2009	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1			388.3	450.5		333.2	317.7	306.9		309.3		
2			390	397.8		361.9	314.1	295.4		292.9		
3		417	370	390		382.1	316.1	296.7	304.1	307.1		
4			360	350		362.4	333.6	302.2	305	310.0		
5			360	351.2		369.3	338.6	300.7	307.9	308.2		
6			375	365		369.4	344.4	283.9	315.1	298.1		
7			374.2	375		391.0	375	278.7	313.4	316.8		
8			410	360		387.1	366.2	276.9	308.8	343.4		
9			385	375	372.1	381.0	335	286.3	282.4	337.1	211.5	
10		438.7	380	390	411.4	354.6	338.6	319.1	304.9	319.8		
11		447.7	360	353.2	403.3	360.0	339.6	306.1	321.7	299.8		
12		442.7	360	356.1	381.2	341.5	338.6	317.5	290.3	291.5		
13		452.2	411.2	340.9	357.4	335.5	332.4	322.4	301.6	285.0		
14		464.8	420	322.4	334	340.0	322.6	328.4	278.6	240.1		
15		452	378.8	371.2	332.2	334.7	321.4	333.9	246.5	209.1		
16		417	368.9	379.5	345.8	346.6	322.4	310.0	269.1	280.0		
17		396.9	386.6	412.1	342	371.5	329.1	328.5	284	305.4		
18		437.2	387.3	396.6	360.1	328.8	312.7	320.2	255.7	290.0		
19		425	383.5		368.1	336.1	295.8	327.5	244.1	310.0		
20		410	360.1	374.2	363.3	339.9	286.2	290.0		307.3		
21		420	432.9	342.6	359.7	326.3	315	293.6	265.6	271.1		
22		440	393.3	332.2	365	330.7	295	280.0	271.5	270.0		
23		440	462.9	343.2	367.7	335.1	310.1	317.2	296.9	260.0		
24		431.9	444		363.5	308.4	335	303.7	306	260.0		
25		421.6	442.4		322.9	293.2	320	287.1	258	260.0		
26		395.6	428.2		338.4	300.7	325	293.7	240	240.0		
27		461.1	403.9		379.4	305.5	327.6	295.0	285.5	290.0		
28		452.2	407.5		397.3	312.8	295	272.5	305.8	284.0		
29		X	417.2		332.6	301.1	307.5	291.4	336.1	259.2		
30		X	438.4		314.7	311.2	300.6	318.9	301.6	247.2		
31		X	475	X	318.9	X	291.8	308.5	X		X	

Table C2. *Daily values of total ozone (DU), Vindeln 2010, Brewer #6*

2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1				345	385	366.7	342.5	291.8	348.1	285		
2			465	365	384.9	368.7	315.2	308.7	336.7	294.6		
3			470	378.5	423.2	398.9	295.7	318.3	328.9	294.4		
4			491.8	401.1	432.4	404.7	327.5	317.3	323.7	285		
5			406.6	425	449.2	401.9	325.8	298.9	298.1	285		
6			426.9	410	450.7	380.8	309.3	310.4	291.7	265		
7			408.7	380	441.9	379.3	351.9	302.5	279.7	270		
8			426.1	381.4	411.6	367.2	316.2	310	276	283.4		
9			449.9	405	422.2	380.2	336.8	310	285.8	272.8		
10			420	398.7	424.9	364.5		310.3	286.3	324.6		
11			424	349.9	424.3	343.3		298.5	266.9	275.6		
12			450	310	396.1	341.2	298.7	294.5	280	275.7		
13			460	392.9	362.4	362.8	299.2	291.3	258.5	254.1		
14			495	311.9	354.4	391.8	311.6	293.4	252	311.8		
15			460	338.7	355.2	372.9	294.1	300.6	280	313.8		
16		355	465	364.1	338.3	351.9	313.9	279	305.4	276.7		
17		380	420	367.6	344	354.8	286.9	277.2	326.7	254.7		
18		420.4	410	409	345.3	350.4	345.1	278.9	321.7	263.2		
19		450	370	391	337.5	385	303.9	296.8	336.4	260	298	
20		490	365	398.4	354.6	384.3	305.7	301.6	325	305		
21			365	397.8	357.5	382.4	297.8	295	300	285	279.5	
22			395	394.4	356.5	390.4	311.3	305	283.8	349.1	273.7	
23			365	417.8	368.8	352.6	333.4	313	295	343.9	363.3	
24			360	422.5	388	345.5	328.5	298.3	295	320.3	350	
25		505	365	419.1	384.3	347.5	340	310	279.7	330	334.2	
26		545		359.4	371.6	365.2	310	330	260.1	310.3		
27				386.6	362.8	331	312.1	333.2	266.8	280		
28				370.8	362.3	339.4	299.7	334.6	264.1	296.6		
29		X	380	349.8	385.4	341.8	288.5	340	255.9			
30		X	370	352.9	379.6	328.5	298.5	340	269.4			
31		X	350	X	366.4	X	272.6	328.5	X		X	

Table C3. *Daily values of total ozone (DU), Vindeln 2011, Brewer #6.*

2011	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		300.7	310.2	290	409.2	348.8	295.9	288.1	303.7	231.0	242.5	
2		336	349.5	285	415	372.6	298.7	285.7	282.4	262.4	266.6	
3			381.2	328.6	383	339.8	301.1	279.0	275.0	240.4	260.0	
4			354.8	390	378.7	335.8	295.8	287.9	265.2	264.8		
5			402.5	387.3	398.4	335.1	314.5	300.0	264.6	275.4		
6			367	390.6	420.4	336.2	301.4	300.0	282.5	285.0		
7				425.8	411.6	327.1	319.7	295.0	295.0	305.0		
8				411.1	367.4	326.6	304.5	320.3	284.2	320.1		
9		371.7		400.6	351.7	336.8	315.4	322.7	286.2	297.8		
10				362.9	355.9	320.3	320.0	323.3	301.2	277.4		
11		403.2		359.3	342.3	322.4	327.6	326.2	271.9	288.7		
12		371.4		353	348.1	310.0	325.7	326.6	279.3	304.8		
13		427.4		386.7	347.3	315.0	348.3	321.3	288.5	280.6		
14	388	388.5		400.8	361	343.2	330.5	313.3	299.6	252.7		
15	429			345.9	376.1	345.0	325.8	307.2	300.9			
16				375	403.4	347.7	345.0	305.0	292.1			
17				359.9	399	346.5	327.2	302.7	305.1	266.0		
18	393	392.3		346.7	402.5	355.6	300.2	300.0	308.2			
19		380		344.4	385.5	355.9	309.0	301.1	300.1			
20		340		381	377.7	375.0	327.1	291.6	301.8	334.8		
21		353.1		398.3	407.8	357.9	310.6	287.6	291.2	306.8		
22		375.8		376.7	361.3	335.8	305.0	295.8	314.8	268.3		
23		415		359.7	344	343.9	301.2	293.0	325.0			
24		317.4		369.5	350.5	345.0	300.2	272.2	315.7	261.0		
25		320	342.3	356.7	392.3	351.5	309.5	276.5	291.9	284.8		
26		296.3	268.9	368	396.7	350.0	317.5	280.0	290.1	277.7		
27		310	277.7	398.8	365.1	341.4	296.6	270.0	329.6			
28	278.1	293.7	281.8	389.4	373.4	304.6	293.1	260.0	316.7			
29	343	X	296.4	417	370	279.4	284.5	269.8	259.5	273.1		
30	293.4	X	282.9	411.6	388.4	293.0	281.0	272.9	227.7	249.7		
31	335	X	260	X	347.5	X	285.6	285.8	X	248.8	X	

Table C4. *Daily values of total ozone (DU), Norrköping 2009, Brewer # 128.*

2009	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	282.2	422.1	362.1	348.1	315.3	334.9	316.6	314.1	263.2	331.6	282.0	362.2
2	298.0	387.5	350.5	330.7	335.5	342.1	299.6	304.7	304.2	320.1	281.4	314.7
3	308.7	409.5	363.8	351.6	307.0	397.1	298.8	312.8	301.8	297.5	277.9	337.3
4	354.1	437.3	356.9	340.6	359.7	397.2	309.5	309.5	330.4	340.9	335.1	298.9
5	304.7	451.1	346.4	358.1	354.4	376.9	325.5	297.2	320.6	293.0	290.7	332.2
6	330.3	472.8	340.4	372.9	358.0	377.5	347.1	291.0	330.7	279.1	292.5	334.0
7	384.3	467.0	365.0	346.3	320.0	377.9	356.0	288.6	297.6	296.7	263.8	326.0
8	336.6	471.7	381.4	343.7	325.9	387.8	352.5	290.3	288.8	294.7	254.9	335.0
9	297.1	429.6	371.6	389.7	383.3	370.5	361.7	298.9	274.6	303.3	242.9	313.6
10	309.3	443.9	386.0	346.0	372.8	364.6	364.0	314.4	292.6	295.6	241.1	328.6
11	307.1	450.0	396.1	324.2	406.2	354.5	349.1	327.1	299.6	289.2	249.6	325.7
12	299.9	409.7	376.1	353.9	368.9	379.0	342.1	321.3	304.4	322.1	269.4	308.0
13	332.9	443.6	388.6	343.1	379.2	357.7	331.3	328.4	307.5	303.9	251.8	304.8
14	349.2	440.2	423.4	319.7	398.3	355.1	340.0	333.1	291.3	290.0	273.5	336.7
15	378.9	438.0	417.4	323.4	371.3	358.0	318.8	310.7	278.8	236.7	267.5	356.5
16	332.1	434.1	338.1	342.5	370.3	363.8	322.8	320.7	274.9	279.5	279.4	359.6
17	363.4	428.4	388.4	349.3	362.3	356.7	316.6	330.2	267.6	312.4	280.2	353.7
18	382.3	430.1	414.3	346.7	386.4	370.2	298.5	343.6	255.8	312.7	306.6	313.7
19	385.7	461.7	373.2	333.6	346.8	363.9	354.2	314.8	254.2	312.9	280.9	327.6
20	397.8	396.0	368.4	335.7	352.3	358.4	322.4	300.6	271.6	314.5	277.2	336.9
21	449.8	389.1	395.9	338.2	358.6	359.0	329.9	297.9	293.6	318.2	293.4	349.4
22	416.5	412.7	398.6	337.9	364.1	355.8	317.4	307.0	291.8	298.9	271.8	346.1
23	399.1	443.1	397.3	326.1	364.2	336.6	313.2	322.9	297.6	272.8	306.5	341.3
24	397.5	375.4	459.8	338.3	337.4	314.5	335.4	296.3	327.3	290.7	325.7	360.9
25	400.2	370.7	419.7	327.5	316.2	317.7	342.8	291.4	302.3	268.0	240.3	349.6
26	365.8	419.1	417.1	337.3	334.7	308.9	337.3	337.1	268.0	293.5	330.6	339.3
27	390.3	402.5	399.5	364.4	349.9	310.5	305.0	285.1	268.4	295.4	349.7	349.2
28	342.9	384.4	410.3	351.5	390.5	312.5	331.7	277.7	301.8	296.3	347.3	364.0
29	371.3	X	433.9	343.6	334.0	308.8	320.5	314.3	322.2	289.8	322.8	421.1
30	390.3	X	400.5	347.8	328.2	310.8	313.2	326.8	310.6	294.5	334.6	410.8
31	395.7	X	360.7	X	335.5	X	343.2	297.2	X	281.8	X	375.4

Table C5. *Daily values of total ozone (DU), Norrköping 2010, Brewer # 128.*

2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	383.5	337.2	431.2	404.5	406.9	363.9	356.1	324.9	326.3	301.3	316.6	325.7
2	350.9	325.5	443.5	429.0	379.2	369.9	325.6	336.2	350.5	297.0	255.6	322.4
3	307.0	336.9	479.7	411.1	357.5	363.7	320.2	330.7	358.3	305.4	282.4	356.3
4	362.5	382.9	470.2	437.3	437.9	388.3	317.7	351.5	346.5	299.1	303.3	361.2
5	328.4	366.3	442.5	463.9	445.6	372.3	335.2	319.1	329.0	297.9	319.5	351.7
6	343.2	416.0	461.2	391.5	392.2	358.5	324.4	324.9	325.4	272.2	306.5	334.2
7	371.8	422.9	406.4	376.1	384.8	357.9	335.1	322.4	325.3	289.0	335.5	350.0
8	389.0	364.7	392.4	378.8	406.4	359.9	330.9	349.9	326.6	284.1	318.1	366.5
9	363.1	365.1	420.1	411.4	423.5	368.8	317.4	339.4	316.0	272.1	291.3	348.7
10	375.1	370.3	422.6	414.6	427.9	356.9	323.2	324.7	327.7	282.0	324.1	301.1
11	363.3	324.6	407.4	385.3	408.9	391.7	317.7	310.7	299.9	290.8	312.3	339.8
12	355.8	322.8	441.0	376.2	372.5	425.0	320.3	308.3	287.2	256.9	329.0	336.3
13	351.7	339.4	437.7	387.6	407.4	364.2	320.3	307.2	297.9	248.7	325.2	343.8
14	342.6	314.0	442.7	324.2	397.2	377.3	306.9	302.6	274.1	268.9	293.0	371.5
15	327.0	322.8	448.4	375.5	367.2	390.5	308.9	304.8	341.2	307.4	327.1	391.3
16	331.9	347.2	434.5	401.1	378.6	369.9	322.8	294.8	343.1	290.3	317.1	380.5
17	340.3	380.1	379.7	359.9	346.8	343.4	315.3	299.3	331.9	259.7	328.9	353.3
18	353.1	401.3	391.3	368.6	332.9	394.5	332.6	316.5	342.2	269.7	312.4	362.5
19	329.0	426.2	370.9	394.2	360.0	*382.8*	310.4	317.4	333.7	299.8	325.7	302.0
20	345.3	445.9	334.2	413.6	356.5	420.3	307.6	311.7	309.6	330.3	321.7	349.8
21	354.4	467.1	370.5	442.8	340.6	417.1	305.9	287.3	301.0	346.6	320.6	387.7
22	331.2	519.9	387.7	453.8	356.0	364.7	322.2	297.6	285.4	371.1	315.9	389.0
23	294.8	528.8	361.6	444.5	365.6	338.4	321.2	309.0	292.3	320.6	323.1	394.7
24	322.0	461.4	355.3	461.9	386.5	337.8	328.6	326.3	295.4	351.4	339.3	371.4
25	314.4	446.2	354.1	390.4	400.0	351.3	337.3	338.1	305.9	368.1	365.1	315.9
26	299.9	459.1	350.3	347.7	394.1	387.3	313.4	339.8	288.6	321.0	362.2	337.9
27	298.7	431.8	390.0	389.2	375.2	325.5	328.8	323.4	271.6	284.8	355.3	345.6
28	348.8	436.9	392.7	373.6	380.1	347.1	337.2	340.9	282.1	293.2	348.8	344.7
29	338.3	X	423.7	368.4	407.2	337.0	344.0	361.8	279.3	293.3	343.5	325.8
30	332.1	X	396.2	374.3	380.1	346.5	349.5	355.0	294.2	250.9	339.7	335.1
31	335.0	X	400.7	X	369.1	X	315.0	345.1	X	269.2	X	312.7

Table C6. *Daily values of total ozone (DU), Norrköping 2011, Brewer # 128.*

2011	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	358.7	324.3	333.7	330.0	397.3	340.0	312.3	297.4	301.8	257.7	256.0	327.7
2	325.6	355.1	336.7	298.4	374.0	321.7	304.3	298.2	288.1	240.0	275.0	335.7
3	330.4	331.7	374.5	320.5	385.9	335.4	302.8	300.4	270.2	242.5	278.8	295.3
4	329.2	366.1	373.5	387.3	385.1	327.9	308.7	302.9	269.1	248.7	265.1	320.9
5	319.6	333.9	403.7	387.2	381.0	328.8	331.1	300.9	280.1	234.0	261.9	361.4
6	333.8	302.8	401.6	359.6	378.3	326.9	324.3	304.2	295.7	250.9	259.0	351.9
7	322.4	299.1	343.6	383.2	370.7	328.5	315.2	300.2	323.8	294.5	282.4	358.8
8	345.6	388.3	348.8	328.8	376.2	339.1	321.4	337.2	312.9	315.3	281.5	336.5
9	308.1	336.6	404.2	320.0	360.8	324.2	332.7	344.4	312.5	302.9	264.2	347.0
10	362.1	427.4	421.8	345.7	360.0	339.2	337.3	345.7	280.1	288.4	262.1	318.0
11	316.4	460.2	408.3	328.8	358.7	340.7	324.0	342.7	264.8	299.6	267.9	243.1
12	373.6	354.4	367.2	347.8	359.6	345.3	347.9	336.0	296.1	298.5	269.8	324.0
13	394.0	369.1	347.3	373.8	371.3	350.2	336.1	326.4	283.0	286.2	290.4	306.0
14	412.9	372.3	381.3	375.2	364.1	342.4	319.9	320.5	315.6	259.2	253.9	328.3
15	413.2	363.6	379.1	334.1	384.5	343.7	336.6	325.2	315.4	249.2	221.0	355.5
16	397.9	406.7	384.9	350.9	411.4	352.4	329.0	324.0	306.6	245.4	259.6	315.7
17	353.3	383.3	378.0	336.2	390.9	372.8	307.3	319.6	295.2	271.1	277.5	301.0
18	386.4	418.1	386.9	336.3	350.0	364.5	315.8	319.9	292.9	315.9	277.2	287.1
19	407.4	364.9	413.9	339.1	345.5	394.6	342.5	298.1	293.2	355.6	253.4	307.4
20	453.6	356.9	413.7	368.6	363.1	365.5	325.1	291.4	284.4	347.4	283.2	298.9
21	426.3	409.0	371.1	353.5	364.4	367.4	316.1	282.3	268.2	295.7	252.3	319.8
22	383.7	416.8	358.8	378.7	348.4	358.1	325.2	305.9	294.6	270.7	250.7	269.2
23	359.1	430.3	359.1	370.6	380.7	360.3	324.6	286.1	293.1	267.5	307.5	271.0
24	341.1	341.5	339.6	363.0	363.5	373.4	346.0	271.5	270.0	278.6	276.4	272.0
25	383.2	332.2	342.2	357.2	390.6	371.1	329.4	302.8	286.5	284.4	251.2	265.0
26	386.5	287.5	316.1	354.5	359.6	353.9	335.0	270.3	268.9	279.9	357.1	238.0
27	314.0	341.0	297.3	362.0	408.3	315.2	318.5	265.2	304.3	285.1	306.3	288.2
28	310.5	338.1	298.4	375.6	371.2	300.3	308.6	294.1	292.2	289.6	311.4	247.0
29	344.0	X	258.0	368.1	395.7	301.1	298.9	301.1	280.9	262.9	290.3	329.8
30	297.3	X	264.0	362.5	332.6	319.6	299.2	291.2	274.4	249.1	311.3	324.2
31	346.6	X	287.2	X	338.4	X	298.4	277.9	X	242.9	X	258.6

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

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					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	2915	.3488	2870	1.1702	3480	1810	Br#185 Sodankylä	0	-0.26	-0.84	-1.9	-3.0	New temp coeff

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						

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1985

1 Hagmarker, A. (1985)
Satellitmeteorologi.

2 Fredriksson, U., Persson, Ch., Laurin, S. (1985)
Helsingborgsluft.

3 Persson, Ch., Wern, L. (1985)
Spridnings- och depositionsberäkningar för avfallsförbränningsanläggningar i Sofielund och Högdalen.

4 Kindell, S. (1985)
Spridningsberäkningar för SUPRAs anläggningar i Köping.

5 Andersson, C., Kvick, T. (1985)
Vindmätningar på tre platser på Gotland. Utvärdering nr 1.

6 Kindell, S. (1985)
Spridningsberäkningar för Ericsson, Ingelstafabriken.

7 Fredriksson, U. (1985)
Spridningsberäkningar för olika plymlyft vid avfallsvärmeverket Sävenäs.

8 Fredriksson, U., Persson, Ch. (1985)
NO_x- och NO_2-beräkningar vid Vasaterminalen i Stockholm.

9 Wern, L. (1985)
Spridningsberäkningar för ASEA transformers i Ludvika.

10 Axelsson, G., Eklind, R. (1985)
Ovädret på Östersjön 23 juli 1985.

11 Laurin, S., Bringfelt, B. (1985)
Spridningsmodell för kväveoxider i gatumiljö.

12 Persson, Ch., Wern, L. (1985)
Spridnings- och depositionsberäkningar för avfallsförbränningsanläggning i Sofielund.

13 Persson, Ch., Wern, L. (1985)
Spridnings- och depositionsberäkningar för avfallsförbränningsanläggning i Högdalen.

14 Vedin, H., Andersson, C. (1985)
Extrema köldperioder i Stockholm.

15 Krieg, R., Omstedt, G. (1985)
Spridningsberäkningar för Volvos planerade bilfabrik i Uddevalla.

16 Kindell, S. Wern, L. (1985)
Luftvårdsstudie avseende industrikombinatet i Nynäshamn (koncentrations- och luktberäkningar).

17 Laurin, S., Persson, Ch. (1985)
Beräknad formaldehydspridning och deposition från SWEDSPANs spånskivefabrik.

18 Persson, Ch., Wern, L. (1985)
Luftvårdsstudie avseende industri-kombinatet i Nynäshamn – depositions-beräkningar av koldamm.

19 Fredriksson, U. (1985)
Luktberäkningar för Bofors Plast i Ljungby, II.

20 Wern, L., Omstedt, G. (1985)
Spridningsberäkningar för Volvos planerade bilfabrik i Uddevalla - energi-centralen.

21 Krieg, R., Omstedt, G. (1985)
Spridningsberäkningar för Volvos planerade bilfabrik i Uddevalla - kompletterande beräkningar för fabrikerna.

22 Karlsson, K.-G. (1985)
Information från Meteosat - forskningsrön och operationell tillämpning.

23 Fredriksson, U. (1985)
Spridningsberäkningar för AB Åkerlund & Rausings fabrik i Lund.

24 Färnlöf, S. (1985)
Radarmeteorologi.

25 Ahlström, B., Salomonsson, G. (1985)
Resultat av 5-dygnsprognos till ledning för isbrytarverksamhet vintern 1984-85.

26 Wern, L. (1985)
Avesta stadsmodell.

27 Hultberg, H. (1985)
Statistisk prognos av yttemperatur.

1986

1 Krieg, R., Johansson, L., Andersson, C. (1986)
Vindmätningar i höga master, kvartalsrapport 3/1985.

2 Olsson, L.-E., Kindell, S. (1986)
Air pollution impact assessment for the SABAH timber, pulp and paper complex.

3 Ivarsson, K.-I. (1986)
Resultat av byggväderprognoser - säsongen 1984/85.

4 Persson, Ch., Robertson, L. (1986)
Spridnings- och depositionsberäkningar för en sopförbränningsanläggning i Skövde.

5 Laurin, S. (1986)
Bilavgaser vid intagsplan - Eskilstuna.

6 Robertson, L. (1986)
Koncentrations- och depositionsberäkningar för en sopförbränningsanläggning vid Ryaverken i Borås.

7 Laurin, S. (1986)
Luften i Avesta - föroreningsbidrag från trafiken.

8 Robertson, L., Ring, S. (1986)
Spridningsberäkningar för bromcyan.

9 Wern, L. (1986)
Extrema byvindar i Orrefors.

10 Robertson, L. (1986)
Koncentrations- och depositionsberäkningar för Halmstads avfallsförbränningsanläggning vid Kristinehed.

11 Törnevik, H., Ugnell (1986)
Belastningsprognoser.

12 Joelsson, R. (1986)
Något om användningen av numeriska prognoser på SMHI (i princip rapporten till ECMWF).

13 Krieg, R., Andersson, C. (1986)
Vindmätningar i höga master, kvartalsrapport 4/1985.

14 Dahlgren, L. (1986)
Solmätning vid SMHI.

15 Wern, L. (1986)
Spridningsberäkningar för ett kraftvärmeverk i Sundbyberg.

16 Kindell, S. (1986)
Spridningsberäkningar för Uddevallas fjärrvärmecentral i Hovhult.

17 Häggkvist, K., Persson, Ch., Robertson, L (1986)
Spridningsberäkningar rörande gasutsläpp från ett antal källor inom SSAB Luleåverken.

18 Krieg, R., Wern, L. (1986)
En klimatstudie för Arlanda stad.

19 Vedin, H. (1986)
Extrem arealnederbörd i Sverige.

20 Wern, L. (1986)
Spridningsberäkningar för lösningsmedel i Tibro.

21 Krieg, R., Andersson, C. (1986)
Vindmätningar i höga master - kvartalsrapport 1/1986.

22 Kvick, T. (1986)
Beräkning av vindenergitillgången på några platser i Halland och Bohuslän.

23 Krieg, R., Andersson, C. (1986)
Vindmätningar i höga master - kvartals-rapport 2/1986.

24 Persson, Ch. (SMHI), Rodhe, H. (MISU), De Geer, L.-E. (FOA) (1986)
Tjernobylolyckan - En meteorologisk analys av hur radioaktivitet spreds till Sverige.

25 Fredriksson, U. (1986)
Spridningsberäkningar för Spendrups bryggeri, Grängesberg.

26 Krieg, R. (1986)
Beräkningar av vindenergitillgången på några platser i Skåne.

27 Wern, L., Ring, S. (1986)
Spridningsberäkningar, SSAB.

28 Wern, L., Ring, S. (1986)
Spridningsberäkningar för ny ugn, SSAB II.

29 Wern, L. (1986)
Spridningsberäkningar för Volvo Hallsbergverken.

30 Fredriksson, U. (1986)
SO_2-halter från Hammarbyverket kring ny arena vid Johanneshov.

31 Persson, Ch., Robertson, L., Häggkvist, K. (1986)
Spridningsberäkningar, SSAB - Luleå-verken.

32 Kindell, S., Ring, S. (1986)
Spridningsberäkningar för SAABs planerade bilfabrik i Malmö.

33 Wern, L. (1986)
Spridningsberäkningar för svavelsyrafabrik i Falun.

34 Wern, L., Ring, S. (1986)
Spridningsberäkningar för Västhamns-verket HKV1 i Helsingborg.

35 Persson, Ch., Wern, L. (1986)
Beräkningar av svaveldepositionen i Stockholmsområdet.

36 Joelsson, R. (1986)
USAs månadsprognoser.

37 Vakant nr.

38 Krieg, R., Andersson, C. (1986)
Utemiljön vid Kvarnberget, Lysekil.

39 Häggkvist, K. (1986)
Spridningsberäkningar av freon 22 från Ropstens värmepumpverk.

40 Fredriksson, U. (1986)
Vindklassificering av en plats på Hemsön.

41 Nilsson, S. (1986)
Utvärdering av sommarens (1986) använda konvektionsprognoshjälpmedel.

42 Krieg, R., Kvick, T. (1986)
Vindmätningar i höga master.

43 Krieg, R., Fredriksson, U. (1986)
Vindarna över Sverige.

44 Robertson, L. (1986)
Spridningsberäkningar rörande gasutsläpp vid ScanDust i Landskrona - bestämning av cyanvätehalter.

45 Kvick, T., Krieg, R., Robertson, L. (1986)
Vindförhållandena i Sveriges kust- och havsband, rapport nr 2.

46 Fredriksson, U. (1986)
Spridningsberäkningar för en planerad panncentral vid Lindsdal utanför Kalmar.

47 Fredriksson, U. (1986)
Spridningsberäkningar för Volvo BMs fabrik i Landskrona.

48 Fredriksson, U. (1986)
Spridningsberäkningar för ELMO-CALFs fabrik i Svenljunga.

49 Häggkvist, K. (1986)
Spridningsberäkningar rörande gasutsläpp från syrgas- och bensenupplag inom SSAB Luleåverken.

50 Wern, L., Fredriksson, U., Ring, S. (1986)
Spridningsberäkningar för lösningsmedel i Tidaholm.

51 Wern, L. (1986)
Spridningsberäkningar för Volvo BM ABs anläggning i Braås.

52 Ericson, K. (1986)
Meteorological measurements performed May 15, 1984, to June, 1984, by the SMHI

53 Wern, L., Fredriksson, U. (1986)
Spridningsberäkning för Kockums Plåt-teknik, Ronneby.

54 Eriksson, B. (1986)
Frekvensanalys av timvisa temperatur-observationer.

55 Wern, L., Kindell, S. (1986)
Luktberäkningar för AB ELMO i Flen.

56 Robertson, L. (1986)
Spridningsberäkningar rörande utsläpp av NO_x inom Fagersta kommun.

57 Kindell, S. (1987)
Luften i Nässjö.

58 Persson, Ch., Robertson, L. (1987)
Spridningsberäkningar rörande gasutsläpp vid ScanDust i Landskrona - bestämning av cyanväte.

59 Bringfelt, B. (1987)
Receptorbaserad partikelmodell för gatumiljömodell för en gata i Nyköping.

60 Robertson, L. (1987)
Spridningsberäkningar för Varbergs kommun. Bestämning av halter av SO_2, CO, NO_x samt några kolväten.

61 Vedin, H., Andersson, C. (1987)
E 66 - Linderödsåsen - klimatförhållanden.

62 Wern, L., Fredriksson, U. (1987)
Spridningsberäkningar för Kockums Plåtteknik, Ronneby. 2.

63 Taesler, R., Andersson, C., Wallentin, C., Krieg, R. (1987)
Klimatkorrigering för energiförbrukningen i ett eluppvärmt villaområde.

64 Fredriksson, U. (1987)
Spridningsberäkningar för AB Åetå-Trycks planerade anläggning vid Kungens Kurva.

65 Melgarejo, J. (1987)
Mesoskalig modellering vid SMHI.

66 Häggkvist, K. (1987)
Vindlaster på kordahus vid Alviks Strand - numeriska beräkningar.

67 Persson, Ch. (1987)
Beräkning av lukt och föroreningshalter i luft runt Neste Polyester i Nol.

68 Fredriksson, U., Krieg, R. (1987)
En överskalig klimatstudie för Tornby, Linköping.

69 Häggkvist, K. (1987)
En numerisk modell för beräkning av vertikal momentumtransport i områden med stora råhetselement. Tillämpning på ett energiskogsområde.

70 Lindström, Kjell (1987)
Weather and flying briefing aspects.

71 Häggkvist, K. (1987)
En numerisk modell för beräkning av vertikal momentumtransport i områden med stora råhetselement. En koefficient-bestämning.

72 Liljas, E. (1988)
Förbättrad väderinformation i jordbruket - behov och möjligheter (PROFARM).

73 Andersson, Tage (1988)
Isbildning på flygplan.

74 Andersson, Tage (1988)
Aeronautic wind shear and turbulence.
A review for forecasts.

75 Kållberg, P. (1988)
Parameterisering av diabatiska processer i numeriska prognosmodeller.

76 Vedin, H., Eriksson, B. (1988)
Extrem arealnederbörd i Sverige
1881 - 1988.

77 Eriksson, B., Carlsson, B., Dahlström, B. (1989)
Preliminär handledning för korrektion av nederbördsmängder.

78 Liljas, E. (1989)
Torv-väder. Behovsanalys med avseende på väderprognoser och produktion av bränsletorv.

79 Hagmarker, A. (1991)
Satellitmeteorologi.

80 Lövblad, G., Persson, Ch. (1991)
Background report on air pollution situation in the Baltic states - a prefeasibility study.
IVL Publikation B 1038.

81 Alexandersson, H., Karlström, C., Larsson-McCann, S. (1991)
Temperaturen och nederbörden i Sverige 1961-90. Referensnormaler.

82 Vedin, H., Alexandersson, H., Persson, M. (1991)
Utnyttjande av persistens i temperatur och nederbörd för vårflödesprognoser.

83 Moberg, A. (1992)
Lufttemperaturen i Stockholm
1756 - 1990. Historik, inhomogeniteter och urbaniseringseffekt.
Naturgeografiska Institutionen, Stockholms Universitet.

84 Josefsson, W. (1993)
Normalvärden för perioden 1961-90 av globalstrålning och solskenstid i Sverige.

85 Laurin, S., Alexandersson, H. (1994)
Några huvuddrag i det svenska temperatur-klimatet 1961 - 1990.

86 Fredriksson, U. och Ståhl, S. (1994)
En jämförelse mellan automatiska och manuella fältmätningar av temperatur och nederbörd.

87 Alexandersson, H., Eggertsson Karlström, C. och Laurin S. (1997).
Några huvuddrag i det svenska nederbördsklimatet 1961-1990.

88 Mattsson, J., Rummukainen, M. (1998)
Växthuseffekten och klimatet i Norden - en översikt.

89 Kindbom, K., Sjöberg, K., Munthe, J., Peterson, K. (IVL)
Persson, C. Roos, E., Bergström, R. (SMHI). (1998)
Nationell miljöövervakning av luft- och nederbördskemi 1996.

90 Foltescu, V.L., Häggmark, L (1998)
Jämförelse mellan observationer och fält med griddad klimatologisk information.

91 Hultgren, P., Dybbroe, A., Karlsson, K.-G. (1999)
SCANDIA – its accuracy in classifying LOW CLOUDS

92 Hyvarinen, O., Karlsson, K.-G., Dybbroe, A. (1999)
Investigations of NOAA AVHRR/3 1.6 µm imagery for snow, cloud and sunglint discrimination (Nowcasting SAF)

93 Bennartz, R., Thoss, A., Dybbroe, A. and Michelson, D. B. (1999)
Precipitation Analysis from AMSU (Nowcasting SAF)

94 Appelqvist, Peter och Anders Karlsson (1999)
Nationell emissionsdatabas för utsläpp till luft - Förstudie.

95 Persson, Ch., Robertson L. (SMHI) Thaning, L (LFOA). (2000)
Model for Simulation of Air and Ground Contamination Associated with Nuclear Weapons. An Emergency Preparedness Model.

96 Kindbom K., Svensson A., Sjöberg K., (IVL) Persson C., (SMHI) (2001)
Nationell miljöövervakning av luft- och nederbördskemi 1997, 1998 och 1999.

97 Diamandi, A., Dybbroe, A. (2001)
Nowcasting SAF
Validation of AVHRR cloud products.

98 Foltescu V. L., Persson Ch. (2001)
Beräkningar av moln- och dimdeposition i Sverigemodellen - Resultat för 1997 och 1998.

99 Alexandersson, H. och Eggertsson Karlström, C (2001)
Temperaturen och nederbörden i Sverige 1961-1990. Referensnormaler - utgåva 2.

100 Korpela, A., Dybbroe, A., Thoss, A. (2001)
Nowcasting SAF - Retrieving Cloud Top Temperature and Height in Semi-transparent and Fractional Cloudiness using AVHRR.

101 Josefsson, W. (1989)
Computed global radiation using interpolated, gridded cloudiness from the MESA-BETA analysis compared to measured global radiation.

102 Foltescu, V., Gidhagen, L., Omstedt, G. (2001)
Nomogram för uppskattning av halter av PM_{10} och NO_2

103 Omstedt, G., Gidhagen, L., Langner, J. (2002)
Spridning av förbränningsemissioner från småskalig biobränsleeldning
– analys av PM2.5 data från Lycksele med hjälp av två Gaussiska spridningsmodeller.

104 Alexandersson, H. (2002)
Temperatur och nederbörd i Sverige 1860 - 2001

105 Persson, Ch. (2002)
Kvaliteten hos nederbördskemiska mätdata som utnyttjas för dataassimilation i MATCH-Sverige modellen".

106 Mattsson, J., Karlsson, K-G. (2002)
CM-SAF cloud products feasibility study in the inner Arctic region
Part I: Cloud mask studies during the 2001 Oden Arctic expedition

107 Kärner, O., Karlsson, K-G. (2003)
Climate Monitoring SAF - Cloud products feasibility study in the inner Arctic region.
Part II: Evaluation of the variability in radiation and cloud data

108 Persson, Ch., Magnusson, M. (2003)
Kvaliteten i uppmätta nederbördsmängder inom svenska nederbördskemiska stationsnät

109 Omstedt, G., Persson Ch., Skagerström, M (2003)
Vedeldning i småhusområden

110 Alexandersson, H., Vedin, H. (2003)
Dimensionerande regn för mycket små avrinningsområden

111 Alexandersson, H. (2003)
Korrektion av nederbörd enligt enkel klimatologisk metodik

112 Joro, S., Dybbroe, A.(2004)
Nowcasting SAF – IOP
Validating the AVHRR Cloud Top Temperature and Height product using weather radar data
Visiting Scientist report

113 Persson, Ch., Ressner, E., Klein, T. (2004)
Nationell miljöövervakning – MATCH-Sverige modellen
Metod- och resultatsammanställning för åren 1999-2002 samt diskussion av osäkerheter, trender och miljömål

114 Josefsson, W. (2004)
UV-radiation measured in Norrköping 1983-2003.

115 Martin, Judit, (2004)
Var tredje timme – Livet som väderobservatör

116 Gidhagen, L., Johansson, C., Törnquist, L. (2004)
NORDIC – A database for evaluation of dispersion models on the local, urban and regional scale

117 Langner, J., Bergström, R., Klein, T., Skagerström, M. (2004)
Nuläge och scenarier för inverkan på marknära ozon av emissioner från Västra Götalands län – Beräkningar för 1999

118 Trolez, M., Tetzlaff, A., Karlsson, K-G. (2005)
CM-SAF Validating the Cloud Top Height product using LIDAR data

119 Rummukainen, M. (2005)
Växthuseffekten

120 Omstedt, G. (2006)
Utvärdering av PM_{10} - mätningar i några olika nordiska trafikmiljöer

121 Alexandersson, H. (2006)
Vindstatistik för Sverige 1961-2004

122 Samuelsson, P., Gollvik, S., Ullerstig, A., (2006)
The land-surface scheme of the Rossby Centre regional atmospheric climate model (RCA3)

123 Omstedt, G. (2007)
VEDAIR – ett internetverktyg för beräkning av luftkvalitet vid småskalig biobränsleeldning
Modellbeskrivning och slutrapport mars 2007

124 Persson, G., Strandberg, G., Bärring, L., Kjellström, E. (2007)
Beräknade temperaturförhållanden för tre platser i Sverige – perioderna 1961-1990 och 2011-2040

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Luftföroreningar i Europa under framtida klimat

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Modelling of surface global radiation and CIE-weighted UV-radiation for the period 1980-2000

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METEOSAT 8 SEVIRI and NOAA Cloud Products. A Climate Monitoring SAF Comparison Study

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Prototyping an improved PPS cloud detection for the Arctic polar night

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The impact of varying NWP background information on CM-SAF cloud products

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Total ozone from zenith radiance measurements. An empirical model approach

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Preliminary use of CM-SAF cloud and radiation products for evaluation of regional climate simulations

132 Bergström, R (2008)
TESS Traffic Emissions, Socioeconomic valuation and Socioeconomic measures Part 2:
Exposure of the European population to atmospheric particles (PM) caused by emissions in Stockholm

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Dagens och framtidens partikelhalter i Sverige. Utredning av exponerings-minskningsmål för PM2.5 enligt nytt luftdirektiv

134 Omstedt, G., Andersson, S (2008)
Vintervägar med eller utan dubbdäck. Beräkningar av emissioner och halter av partiklar för olika dubbdäcksscenarier

135 Omstedt, G., Andersson, S., Johansson, Ch., Löfgren, B-E (2008)
Luftkvalitet och småskalig biobränsle-eldning. Tillämpningar av SIMAIRved för några kommuner

136 Josefsson, W., Ottosson Löfvenius, M. (2009)
Measurements of total ozone 2006-2008

137 Andersson, S., Omstedt, G (2009)
Validering av SIMAIR mot mätningar av PM10, NO_2 och bensen.
Utvärdering för svenska tätorter och trafikmiljöer avseende är 2004 och 2005

138 Wern, L., Bärring, L (2009)
Sveriges vindklimat 1901 – 2008
Analys av förändring i geostrofisk vind

139 Wern, L., German, J (2009)
Korttidsnederbörd i Sverige, 1995 – 2008

140 Omstedt, G., Andersson, S., Bergström., R (2010)
Dagens och framtidens luftkvalitet i Sverige. Haltberäkningar av NO_2, PM10 och PM2.5 i svenska trafikmiljöer för framtidsscenarier med minskade europeiska emissioner

141 Wern, L., Isaksson, L (2010)
Åska i Sverige 2002 – 2009

142 Andersson, S., Omstedt, G., Robertson, L (2010)
Känslighetsanalys, vidareutveckling och validering av SIMAIRs urbana spridnings-modell BUM

143 Wern L., (2010)
Extrem nederbörd i Sverige
under 1 till 30 dygn, 1880 – 2010

144 Omstedt, G., Andersson, S., Bennet, C., Bergström, R., Gidhagen, L., Johansson, Ch., Persson, K (2010)
Kartläggning av partiklar i Sverige – halter, källbidrag och kunskapsluckor

145 Engardt, M., Andersson, C., Bergström, R (2010)
Modellering av Marknära Ozon
- Regionala och högupplösta tillämpningar av MATCH

146 Omstedt, G., Forsberg, B., Nerhagen, L., Gidhagen, L., Andersson, S (2011)
SIMAIRscenario – ett modellverktyg för bedömning av luftföroreningars hälsoeffekter och kostnader

147 Andersson, C., Andersson, S., Langner, J och Segersson, D (2011)
Halter och deposition av luftföroreningar - Förändring över Sverige från 2010 till 2020 i bidrag från Sverige, Europa och Internationell Sjöfart

148 Carlund, Th., (2011)
Upgrade of SMHI’s meteorological radiation network 2006-2007 – Effects on direct and global solar radiation

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Swedish Meteorological and Hydrological Institute
SE 601 76 NORRKÖPING
Phone +46 11-495 80 00 Telefax +46 11-495 80 01

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