GAW Report No. 176

The Tenth Biennial WMO Consultation on Brewer Ozone and UV Spectrophotometer Operation, Calibration and Data Reporting

(Northwich, United Kingdom, 4 to 8 June 2007)
THE TENTH BIENNIAL WMO CONSULTATION ON BREWER OZONE AND UV SPECTROPHOTOMETER OPERATION, CALIBRATION AND DATA REPORTING

(Northwich, United Kingdom, 4 - 8 June 2007)

Edited by: C. T. McElroy and E. W. Hare

Organised by: C. T. McElroy, J. Rimmer and E. W. Hare

Chairpersons: C. T. McElroy and J. Rimmer
Rapporteur: E. W. Hare
FOREWORD

The year 2007 is a special year for the Brewer community. There are now almost 200 Brewer Ozone Spectrophotometers of different types in the Global O₃ Observing System operating in more than 30 nations. While each of these instruments has the potential to make the ozone and ultraviolet radiation measurements crucial to determining the future evolution of the UV radiation environment, some are not performing up to expectations. In order to ensure the availability of the highest quality data for the future assessment of the ozone layer and ultraviolet environment, it is essential that the data collected by individual instruments, including test and inter-comparison results, be archived in the WMO World Ozone and Ultraviolet Radiation Data Centre (WUDOC). Thus, an accurate and detailed retrospective analysis can be uniformly carried out on the data from all stations in the Global Observing System.

The focus of these meetings has shifted slightly in terms of the meeting programme. Instead of being solely a scientific and technical meeting, tutorial sessions have been added to focus on the operations and basic science of the Brewer UV and Ozone Spectrophotometer. Traditional plenary sessions continue to be an important part of the workshop to allow participants to make presentations. Further, The Sixth meeting introduced poster sessions to the workshop a move which has been well received and a useful means for further interaction among participants.

The Brewer Workshop meetings are a crucial part of the process of ensuring that all Brewers are properly operated and that instrument calibrations are tightly traceable to international standards.

C.T. McElroy
June 2007
# TABLE OF CONTENTS

**Foreword**

1. **Formal Introduction of the Meeting and Welcome** .......................................................... 1

2. **Opening Address by the Meeting Chairman** .................................................................. 1

3. **Special Session: Tutorial** ................................................................................................. 1
   3.1 Physical Principles I: The Dobson, Measuring Ozone, A Historical Perspective ............... 1

4. **Session I: Station Observations and Data Comparisons** ................................................. 2
   4.1 Comparison between Brewer and Dobson Total Ozone Measurements at Arosa, Switzerland ......................................................... 2
   4.2 O₃, SO₂, NO₂ and UV-B Measurements with Brewer Spectrophotometer at Maitri, Antarctica .............................................................. 3
   4.3 Homogenized Brewer Triad Total Ozone Records from Arosa, Switzerland ...................... 3
   4.4 Comparison of Brewer and Dobson Instruments at Seoul, Korea ....................................... 5

5. **Session II: Tutorials** ......................................................................................................... 6
   5.2 Physical Principles III, Brewer Stray Light Issues ............................................................ 7

6. **Session III: Data Retrievals and New Techniques** .......................................................... 7
   6.1 The Short-term and Long-term Tropospheric Ozone Variability Available from Zenith Sky Measurements ................................................................. 7
   6.2 New Remaining Issues Concerning Satellite/Ground-based Column Ozone Retrievals ........ 9
   6.3 Data Quality Considerations in the Global Ground-Based Network .................................. 10
   6.4 Technical Panel Report ..................................................................................................... 11
   6.5 Ozone Absolute Langley Calibration .................................................................................. 12

7. **Session IV: Other Methods** .............................................................................................. 14
   7.1 Brewer Algorithm Sensitivity ......................................................................................... 14
   7.2 Validation of the Method for Retrieving Aerosol Optical Depth Obtained with the Langley Plot Method using a Brewer ........................................... 15
   7.3 Kipp and Zonen Updates ................................................................................................... 17
   7.4 The 6th Brewer Sub-Committee Meeting .......................................................................... 18

8. **Session V: Keynote Speaker - J. Shanklin, British Antarctic Survey** ............................. 18

9. **Session VI: UV Studies, Calibrations and Data Analysis** .............................................. 20
   9.1 Applying SL Corrections to ETC for DS Observations ..................................................... 20
   9.2 SAUNA II Preliminary Results ....................................................................................... 22
   9.3 Total Ozone and UV Radiation Measurement Programme in the Italian Air Force Met Service Background Air Pollution Monitoring Network ......................................................... 24

10. **Session VII: Software and Analysis Techniques** ............................................................ 25
    10.1 Brief RBCC-E Campaign Update .................................................................................... 25
    10.2 Brewer Health Diagnostic Database ................................................................................. 25
    10.3 Brewer Ozone and UV Processing and Analysis Software ............................................... 26
    10.4 Brewer Software Development ...................................................................................... 27
    10.5 WOUDC and BDMS ....................................................................................................... 29

11. **Session VIII: Discussion and Recommendations** ........................................................ 30

12. **Poster Sessions – Abstracts** .......................................................................................... 31

13. **Closing Sessions – Abstracts** ......................................................................................... 36

Annex A: List of Participants .................................................................................................. 37
Annex B: Final Agenda .......................................................................................................... 39
Annex C: List of Acronyms and Abbreviations .................................................................... 43
1. **FORMAL INTRODUCTION OF THE MEETING AND WELCOME**

J. Rimmer on behalf of the University of Manchester and the local hosts welcomed everyone to the meeting and expressed his hope for fruitful and successful discussions.

2. **OPENING ADDRESS BY THE MEETING CHAIRMAN**

C.T. McElroy of Environment Canada thanked J. Rimmer and A. Webb for hosting the meeting. He also thanked and acknowledged the efforts of the University of Manchester staff who assisted with the meeting preparations.

The importance of these workshops for participants was emphasised, since they bring together interested Brewer instrument users and provide a forum which has proven to be successful in maintaining continuity within the Brewer community. An important point has been reached by the Brewer community and a change in the approach to the theme and timing of the meetings was needed. In the past, the meetings were held in even-number years to coincide with the Quadrennial Ozone Symposium (QOS), at every other meeting. But it was determined that this approach had outlived its usefulness and that participants were too tired to fully engage in the meetings held during the QOS years. Thus, by having the meetings in the odd-number years, the important role of the workshops in providing a forum where the participants are able to interact in a relaxed and informal atmosphere was emphasised. This has resulted in an increased attendance.

3. **SPECIAL SESSION: TUTORIAL**

3.1 **Physical Principles I: The Dobson, Measuring Ozone, a Historical Perspective**

(C.T. McElroy)

McElroy mentioned that the rationale for this meeting being held in the United Kingdom was to remember and acknowledge the contributions of the British to ozone science, in particular, the contributions of Dobson and Brewer. A picture of the original International Ozone Commission (IOC) taken from the 1930’s indicated an attendance level comparable to the present-day Brewer workshops. It was also mentioned that Alan Brewer had considered attending the meeting, but unfortunately a schedule clash and his advancing years, argued against it.

Although this is a Brewer Workshop, but recognising the significance of the British effort, a historical perspective on ozone and the Dobson seems appropriate especially with the year 2007 being the anniversary of the IPY and the Montreal Protocol (20th). Thus, McElroy gave an overview of ozone science and the efforts in the early years.

For a copy of the presentation, refer to the meeting summary web site.

**Question 1:** When you make a quasi-Langley plot to determine a zero-ozone value, what are the other effects such as changes in the temperatures (for example during the morning when the temperature gradients are greater)? Also what about the quartz window and other instrument-related effects? **Answer:** First, large amounts of haze and aerosol can effect the measurement. Thus, a site such as MLO, USA is useful because during the morning there are generally clear observing conditions and stable ozone, which make this location ideal for doing Langley plots.

**Question 2:** Doesn’t the PMT have a temperature dependence? **Answer:** Yes. There are also polarization effects. The Brewer has a de-polarizer to reduce this effect. The effect is generally small on DS measurements since it is un-polarised light.
4. SESSION I: STATION OBSERVATIONS AND DATA COMPARISONS

4.1 Comparison between Brewer and Dobson Total Ozone Measurements at Arosa, Switzerland (J. Stähelin)

J. Stähelin from ETHZ, Switzerland presented a comparison between the Dobson and Brewer instruments co-located at Arosa, Switzerland (46.8 N, 9.68E, 1820 m.a.s.l.). The principal effort for this study was contributed by B. Scarnato, but she was unable to attend the workshop to present this work from her PhD thesis. The initial work of J. Kerr back in the 1980’s, examining the co-located instruments was acknowledged. A brief overview of the previous work in this area was presented.

Ozone effective temperatures were extracted from the observations. The estimated temperature dependence with the observation for classes of $\mu$ times ozone was presented in terms of agreement with the observations.

A quantitative estimate of the amplitude of seasonal variation determined from the temperature effect of ozone cross-sections and $\mu$ dependence on ozone. The amplitude of this seasonal variation is reduced by a factor of about two.

However, ozone cross-sections and their temperature dependence are rather different for the Bass and Paur (B-P) spectra (used here) and those used in current satellite retrievals (GOME). The preliminary results suggest that the difference between Dobson and Brewer data can be better explained when using Bass and Paur data than spectral data used in GOME retrieval algorithm.

In conclusion,

1. Do not replace a Dobson by a Brewer instrument without an overlap of quasi-simultaneous measurements of at least 3 years.
2. Empirical transfer functions can be constructed for adjustment of Brewer to Dobson total ozone measurements (if ozone profile measurements of the site are not available lower stratospheric temperature data can be used).
3. Differences between total ozone measurements can be well explained when using temperature dependence of the ozone cross-sections of Bass and Paur.
4. Preliminary results suggest larger differences when the temperature dependence of the ozone cross-sections of current satellite retrievals (GOME) is used.

Many believe that the B-P scale is not the best spectrum and future studies will continue to look into this issue and more work is required.

Future work will require:

- Reliable total ozone measurements required to document recovery and for satellite validation (http://www.wmo.int/web/arep/reports/ozone_2006/exec_sum_18aug.pdf).
- Effect of “super recovery”: i.e. more ozone in troposphere (strong greenhouse gas and air pollutant) Reference: Correlation between ozone trends in the lower most stratosphere and high mountain sites in Europe (Ordonez et al., 2007).

Question 1: Could we measure ozone temperature using both instruments? Answer: two reasons for simultaneous measurement – ozone effective temperature, plus use ozone profile measurement

Comments: V. Savastiouk: even if the Brewer and Dobson were to measure the same wavelengths, it is the way you measure ozone that is important and thus the products may be different. G. Labow, chlorine isn’t the only chemical that is important. Bromine also needs to be considered. McElroy responded that bromine is included. Stähelin, only the halogens are
considered but not NO$_2$. McElroy added that the SOPs for the Dobson uses AD or CD depending on the air mass, the temperature coefficient is likely different for the AD and CD wavelength pairs. Stähelin, the Dobson uses the CD regularly for larger air mass values.

4.2 O$_3$, SO$_2$, NO$_2$ and UV-B Measurements with Brewer Spectrophotometer at Maitri, Antarctica (S. Peshin)

S. Peshin of the Indian Meteorological Department (IMD) gave an overview of the work at the Maitri station in the Antarctica as depicted in Figure 1. The station opened in 1999 and the observation programme includes routine measurements of total column ozone (with Brewer instrument #153) and regular ozonesonde launches.

![Figure 1: The Maitri station facility, Antarctica.](image)

The eight-year time series, beginning in 1999, including total column O$_3$, SO$_2$ and UB-V was shown. Several plots comparing the SO$_2$ and O$_3$ to the UV-B showed a positive trend. Brewer data (O$_3$ and UV-B were shown for each year from 1999 to 2005. Several ozonesonde flights were also shown representing the years 2003 and 2004.

4.3 Homogenized Brewer Triad Total Ozone Records from Arosa, Switzerland (H. Schill)

H. Schill of MeteoSwiss presented results from the homogenization of the Brewer triad (BR#040, BR#072 and BR#156), total ozone records from the Arosa site in Switzerland. Refer to Figure 2. The accuracy of the instruments for single measurements is between 1-2%. What are the possibilities to improve data quality of ozone measurements?

- Use of parallel instruments of the same type.
- Use of different instrument systems for the measurement of the same entity (e.g. total ozone); take into account of the instruments inherent characteristics.
- Performing of regular standard lamp tests and its full use for the monitoring of the instruments stability.
- Calibrate instruments versus an approved standard instrument.
- A combination of the above techniques.

The Brewer triad is regularly calibrated against the travelling standard (BR#017) and has been done every year since 1998. The daily average SL (R6) tests 4-6 times per day is used as a calibration indicator. Subsequently, these SL test values lead to a definition of the ETC’s making use of a 30 day running mean. Refer to Figure 3 for the R6 plots.

$$\text{ETC (O}_3\text{)}_t = \text{ETC (O}_3\text{)}_0 + (R6_t - R6_0)$$
A comparison of the total ozone daily means implied the following conditions:

1. Single measurements meet following requirements: $\text{StaDev} \leq 2.5$, $\mu \leq 5.0$.
2. Quasi simultaneous measurements: $\Delta T \leq 5$ mins, $\Delta \mu \leq 0.05$, outliers flagged, i.e. not used.
3. Using relative differences of single measurements between two Brewers: $\text{RelDiff} = 100 \times (\text{OzBr}_1 - \text{OzBr}_2) / \text{OzBr}_1$.

What are the possibilities for correction?

1. Correcting which of the two instruments: one, the other, or both?
2. Which SL- and ETC-values as references: begin or end of a period?
3. Reasons for drifts: Standard lamp, Instrument, Reference Brewer?

The total ozone inter-comparison of the Brewers from 1998 to 2007 and their subsequent calibrations are shown in Table 1 with the offset for daily mean relative difference between two Brewers.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>040-072</td>
<td>0.18 % $\pm$ 0.56 %</td>
<td>-0.05 % $\pm$ 0.64 %</td>
</tr>
<tr>
<td>040-156</td>
<td>-0.04 % $\pm$ 0.6 %</td>
<td>0.18 % $\pm$ 0.56 %</td>
</tr>
<tr>
<td>072-156</td>
<td>-0.21 % $\pm$ 0.6 %</td>
<td>0.22 % $\pm$ 0.45 %</td>
</tr>
</tbody>
</table>

In conclusion, three elements are important:

1. Use of parallel instruments of the same type.
2. Performing of regular standard lamp tests and its full use for the monitoring of the instruments stability.
3. Calibrate instruments versus an approved standard instrument.

The combination of these techniques reduces the relative differences of daily means between two Brewer instruments to less than 0.5 %.
Question 1: Is the 0.5% the standard deviation?  Answer: The 0.5 is the offset plus standard deviation. All three instruments are within the ±0.5% for the day-to-day variations in the relative difference.

Question 2: One of the triad instruments is a MKIII the others are MKII’s, so what are the differences under large SZA conditions?  Has any statistical analysis been done this??  Answer: No, not as yet.

Question 3: Have you gone back to re-analyse the entire time series because of the behaviour of the early data?  Answer: No.

4.4 Comparison of Brewer and Dobson Instruments at Seoul, Korea  
(J. Kim et al.)

J. Kim from Yonsei University, Korea presented an overview of the Brewer and Dobson measurements at Seoul, Korea including the ozone observatory and measurement programme. The observatory and its programmes began in 1984, initiated by Prof. H.K. Cho. A Dobson instrument (D#124) has been in operation since 1984 and a Brewer instrument (BR#148) since 1997. The Brewer is operated by the university staff, while the Dobson operation is a collaborative effort between the university and the Korean Meteorological Administration (KMA). The KMA also operates a Brewer (BR#095) at Pohang and the Korea Polar Research group (KOPRI) operates a Brewer (BR#122) at King Sejong station in the Antarctica. Ozonesonde and lidar measurements are also activities that are part of these collaborations.

Much effort has been given to the Dobson and Brewer regular calibrations and comparison of these data sets. There have been hardware issues resulting from high humidity with the Dobson instrument and so it was converted into an automated system in 2005-06. By enabling an automated observation schedule, the result has been improved data quality, especially when comparing the Dobson to Brewer instrument. Refer to Figure 4.

![Figure 4: Comparison of the Dobson and Brewer instruments before and after the Dobson automation process.](image)

Some results of work done with SO₂ effects, taking into consideration cloud effects, made use of regression analysis (Brewer = Dobson + (-1.136*SO₂ + 1.325)). The results of a comparison between the Brewer and Dobson instruments are shown, before and after automation, in Figure 5. Kim emphasised that this work has been done in conjunction with KMA and KOPRI.
In summary, after the automation process the Dobson spectrophotometer results are considerably more accurate, seen especially in comparison with the Brewer instrument. With the SO\textsubscript{2} correction, the agreement between the Brewer and Dobson is reasonably good.

Question: Were the measurements simultaneous? Answer: Before the automation, it was only the daily representative values that were compared, but after the automation, they were simultaneous. A general comment was made that a standard brewer using the 22 km ozone layer height will cause problems at high latitudes.

5. SESSION II: TUTORIALS


D.I. Wardle of Environment Canada gave a special tutorial presentation on the spectral characteristics of the Brewer instrument with emphasis on the measurements, interpretation and usefulness. Included in the presentation was a discussion on characterising the UV beyond 327 nm. (out to 338 nm.). The responsivity is mostly determined by the optical characteristics of the NiSO\textsubscript{4} filter and the stability of the filter is important.

The main concluding remarks were:

1. Stray light affects ozone measurement by all single Brewers.
2. The best choice for alpha values is weighting by the solar spectrum absorbed by a typical slant column ozone.
3. We seem to have been unlucky with the alphas used to date; various chance coincidences between extrema of the solar spectrum and the ozone absorption spectrum within the slit pass-bands change the ozone values by more than 1%.
4. It is ok not to use variable alphas.

For a copy of the presentation, refer to the meeting summary web site.

Question 1: Did you characterise only one slit? Answer: Yes. Volodya is convinced one slit is ok.

Question 2: Are the instruments from the same year or different years of production? Answer: I don’t know, but will check (BR#009-BR#084?). Quite different years.
5.2 Physical Principles III, Brewer Stray Light Issues (C.T. McElroy)

McElroy gave a tutorial presentation on the stray light characteristics of the Brewer. In a general overview the rationale for these considerations of stray were discussed. For global column ozone, one must develop confidence in prediction of the future (ozone). Models are tuned to reproduce current measured amounts, but one also must reproduce measured values during the past 20 years. The target accuracy is 1.0% 2-sigma. (or maybe 2 or 3 DU). It is reasonable to have 20-50 (?) instruments deployed all over the world validating the measurements from space-based instruments? Over the last 20 years we have almost achieved 1.0% RMS for daily average measurements with our best 3 instruments in Toronto.

In summary, McElroy emphasised:

1. We are learning a great deal about the Brewers with laser scans.
2. We need to help Tom and Mike with establishing rules on how to do laser scans in the field.
3. We also need to propagate this information to the rest of the Brewer community.

For a copy of the presentation, refer to the meeting summary web site.

Question: Are the slits the same for all three types of Brewer? Answer: Yes. If the grating slits are smaller then the aberration width, then you loose energy, at least at 340 nm.

6. SESSION III: DATA RETRIEVALS AND NEW TECHNIQUES

6.1 The Short-term and Long-term Tropospheric Ozone Variability Available from Zenith Sky Measurements (I. Petropavlovskikh)

I. Petropavlovskikh from NOAA gave a presentation on the tropospheric ozone variability derived from zenith sky measurements. The purpose is to study the effects of tropospheric air quality and clouds on surface UV radiation. The presentation began by presenting what is new in terms of the measurement programme. As in the previous EPA Network, the NEWBREW network will provide calibrated UV solar irradiance from 290 - 363 nm from Mark IV Brewer Spectrophotometers. The NEWBREW network will provide calibrated total ozone measurements and ozone altitude profiles will be produced. The NEWBREW network was designed to be collocated with several existing radiation and aerosol networks. (The Mark IV Brewer spectrophotometer can measure SO₂ and has the potential of measuring NO₂). Applications include: UV Forecasts, Satellite Estimates of UV, UV climatology, health and epidemiological studies, plants, agricultural products, and ecosystems, photolysis rates, photochemistry and material degradation.

The objectives are:

1. To evaluate the quality of tropospheric ozone information derived from the ground-based Dobson and Brewer measurements.
2. Validate Umkehr-derived tropospheric ozone data through comparisons against co-incident ozonesonde measurements of high vertical resolution.
3. Concentrate on the short-term and long-term tropospheric ozone variability in data available from Boulder, CO (middle latitude) and Mauna Loa Observatory in Hawaii (subtropical station).

A discussion of UV and ozone profiles centred around how sensitive UV flux is to the vertical distribution of ozone. Knowledge of the location of the ozone maximum is important for UV modelling (Klenk et al., 1983; Wellemeyer et al., 1997). Ozone profile variability (Krotkov et al., 1998) shows the following effects:
• The stratosphere where spectral dependence in UV response (up to a few percent) increased when sun is low.
• The upper troposphere - has a small effect on the UV flux.
• The lower troposphere - more significant at high sun conditions due to increased scattering in troposphere relative to stratosphere.

It is intended to account for the effects of ozone profiles (derived from Brewer Umkehr measurements) in the analysis of the Brewer-measured UV fluxes. An ozone sounding is not always available at the UV sites, except for Boulder, CO (once a week) and Houston, TX (during the pollution season)

Comparisons of ozonesondes and Umkehr retrievals from long-term ozonesonde measurements in Boulder, CO (since 1979) and Mauna Loa (MLO), HI (since 1982) were presented. The soundings were in close vicinity to Dobson and Brewer measurements and done about once a week. The Dobson/Brewer measurements are done daily with the exception of overcast conditions (Dobson: ~272/year in MLO, ~146/year in Boulder).

There are 4 types of operational Umkehr systems: traditional Dobson, automated Dobson and Brewer (single and double). Only single-pair data from the automated Dobson are used for ozone profile retrievals in UMK04 algorithm, even though Dobson also takes measurements at other wavelength pairs. The Dobson UMK04 algorithm was adapted to process Brewer data taken at single pair wavelengths (310 and 326 nm). Some assumptions were considered:

• Brewer measurement noise is assumed to be half of Dobson or comparable.
• First Brewer UMK04 RT was tested on Arosa, Switzerland dataset.
• Dobson and Brewer ozone profiles appeared to have biases.
• Moreover, Brewer data processing had no cloud detection capabilities – use co-incidence with Dobson data that are screened for clouds
• New software was developed by M. Stanek (Czech Republic) based on UMK04, it includes the first attempt to screen data for clouds.

In summary,
1. The Dobson Umkehr technique is capable of monitoring short-term variability in tropospheric ozone. It can explain about 50% of the variability measured by sonde.
2. The 1-day co-incident data have higher correlation coefficients than the 2-day window for Boulder, but not for Mauna Loa.
3. Correlation coefficients in the troposphere are relatively large and statistically significant, although the best correlations are in the lower stratosphere.
4. Smoothed sondes show larger correlation coefficients than layer-integrated ones.
5. Based on correlation analysis Umkehr data can capture tropospheric ozone variability.
6. Umkehrs are capable of measuring long-term changes in tropospheric ozone.

In closing, a brief presentation on the cloud clearing procedure was given. The motivation for this study is an EPA proposal, “Effect of clouds and tropospheric air quality on surface UV at six EPA UV research sites”. by K. Lantz (PI), I. Petropavlovskikh (Co-I), P. Kiedron (Co-I) using the ground-based “NEWBREW” Network of Brewers in US (P. Disterhoft, P. Kiedron, S. Sterlie, NOAA/CIRES). The objectives are to develop ozone retrieval algorithm for Brewers, optimize it for tropospheric ozone retrievals, validate the retrievals against ozone-sounding and thus, develop cloud screening techniques.

The plan is to plot the difference in Umkehr N-values at the 319 nm channel taken in two sequential scans (as suggested by C.T. McElroy).
The preliminary results conclude that it is possible to use the 319 nm channel for detection of clouds. It is possible to derive cloud correction fit for one instrument and apply it to a different instrument at the same location and it is better to derive cloud correction fit for instrument at different locations.

6.2 New Remaining Issues Concerning Satellite/Ground-based Column Ozone Retrievals

(G. Labow)

G. Labow of NASA-GSFC began his presentation alluding to the “symbiotic” relationship between the satellite community and the ground-based network personnel. An “incomplete list of outstanding issues” was used to focus the discussion. These issues include:

- Ozone profile climatology.
- Profile shape effects.
- Cross-section errors.
- SO₂ contamination.
- Stray Light.
- Aerosols.
- Cloud heights.

In terms of cross-section errors, a comparison of OMI residuals compared to TOMS v. 8 and Brewer data was shown and is given in Figure 6. What do these results mean?? There are possible errors due to cross-sections. Table 2 outlines the various cross-sections and the relative differences.

<table>
<thead>
<tr>
<th>@-44C</th>
<th>B&amp;P</th>
<th>Daumont</th>
<th>Diff(%)</th>
<th>Temp (%/K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dobson A-D</td>
<td>1.432</td>
<td>1.430</td>
<td>0.0</td>
<td>0.014, 0.008</td>
</tr>
<tr>
<td>Dobson C-D</td>
<td>0.459</td>
<td>0.461</td>
<td>-0.3</td>
<td>0.014, 0.015</td>
</tr>
<tr>
<td>TOMS V8</td>
<td>0.319</td>
<td>0.314</td>
<td>1.5</td>
<td>0.014, 0.010</td>
</tr>
<tr>
<td>Brewer</td>
<td>0.324?</td>
<td>0.340</td>
<td>(-4.6 or 0)?</td>
<td>0.097, 0.055</td>
</tr>
<tr>
<td>0.339 &amp; 0.338 (Kerr et al 2002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Labow suggests that the community continue to do ground-based ozone studies for the next 50 years to get a better understanding of the trends. There are profile issues as the satellite data have been determined to be more sensitive in the lower layers such as Umkehr layers 1-3, more so then first thought. Cross-section errors Bass and Paur versus Daumont need further examinations. Comparison of OMI residuals for one clear sky pixel – illustrated that differences are likely coming from the cross-section differences – what does this mean to the various instruments?

The conclusions are:

Cross-sections (Work in progress (WIP))
Ozone profiles (done)
Temperature (done)
SO₂ (done)
Tropospheric Aerosols (done)
Stratospheric Aerosols (?)
Clouds (WIP)
Improved Radiative Transfer (WIP)
  - Ring Correction (Raman Scattering)
  - Better Surface Reflectivity Climatology
  - High SZA Issues
  - Better Pseudo-spherical Approx

Cross-sections, (WIP)
Ozone Profiles, peak height assumption (?)
Temperature (WIP)
SO₂ (WIP)
Stray Light (WIP)
ZS v. DS Differences (?)
Wavelength Registration (?)!!

McElroy commented that we may not know ozone cross-sections to better than 2-3% and that we are aware of the temperature dependence to better then 5%. Most Brewers are not using optimal weighting for the 5 wavelengths and there are no temperature corrected data available from the WOUDC yet. The difference in air mass factors, especially for high-latitude sites should also be considered.

6.3 Data Quality Considerations in the Global Ground-Based Network (V. Fioletov)

V. Fioletov of Environment Canada presented a summary of a data quality assessment of the column ozone from the ground-based data, mostly derived from the WOUDC. The presentation is similar to the Labow presentation except from a different perspective. A list of publications showing the comparison of papers from satellite studies to those from either the Dobson or the Brewer revealed that there are more satellite studies then ground-based, greater then 3 to 1 since the year 2000.

Annual mean deviations from the 1958-1980 averages estimated from four Canadian stations: Toronto, Edmonton, Goose Bay, and Churchill, and from merged satellite data set for (area-weighted average for 35-60N) was presented. The satellite deviations were adjusted to match mean deviations over Canada over the period when both data sets are available. Figure 7 is a times series of these data records.

![Figure 7: Time series from 4 Canadian stations compared to annual mean (1958-1980).](image)
The data from the WOUDC were put into five “bins” beginning with the satellite records, 1978-present. This method was used to establish a baseline for long term data quality assessment. A general statement is the 10% worst Brewer records are “worst” then the worst 10% of the Dobson data. Table 3 shows the summary results of this “bin” analysis and Table 4 gives a summary of the data quality assessment exercise. Suspect and outlier criteria are contained within Table 4 and apply to the number of the data files archived at the WOUDC.

Table 3: Comparison of data issues from stations with long records (3 or more bins) and various instruments.

<table>
<thead>
<tr>
<th></th>
<th>Dobson</th>
<th>Brewer</th>
<th>Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stations with data from 3 or more bins</td>
<td>81</td>
<td>46</td>
<td>44</td>
</tr>
<tr>
<td>Within the range</td>
<td>42</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>Minor issues (3 blue dots or 1 red +1 blue or less)</td>
<td>19</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Major issues (more than minor)</td>
<td>20</td>
<td>14</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 4: Results of the data assessment exercise showing suspect/outlier criteria.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>DS Observations</th>
<th>ZS Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean difference</td>
<td>-4</td>
<td>-5</td>
</tr>
<tr>
<td>Standard deviation of daily difference</td>
<td>3.7</td>
<td>4</td>
</tr>
<tr>
<td>Standard deviation of monthly difference</td>
<td>3.7</td>
<td>4</td>
</tr>
<tr>
<td>Seasonal amplitude of the difference</td>
<td>2</td>
<td>2.6</td>
</tr>
<tr>
<td>Range of annual mean differences</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

6.4 Technical Panel Report (C.T. McElroy)

McElroy gave a brief summary of the technical panel meeting which met in April 2007 in Tenerife, Spain. The WMO created this sub-committee to report on the quality of data from both satellite and ground-based data, appropriate for use in trend analysis. An additional rationale is that Satellite data are a useful tool for evaluating the temporal and spatial consistency of ground-based data and that changes in the relationship between satellite and ground-based data can provide an indication that there are problems in the ground-based record.

The analysis consisted of two independent analyses by G. Labow (from a satellite data perspective) and by V. Fioletov (from a ground-based instrument network perspective), each using a different approach. The results were presented to the committee, each station’s results were discussed and a short assessment was written up for each comparison. A WMO report is being prepared which describes the work of the committee.

A number of problems were identified in both the Dobson and Brewer data sets. Annual cycles between ground and satellite which includes ETC errors in ground-based instruments and difference in the effective temperature coefficients (possibly correctable with estimated temperatures or using different wavelength weighting coefficients). The 1-parameter fit versus the
2-parameter fit in the Brewer (see change in Hohenpeissenberg record in 1993) and inaccurate airmass factors, high-latitude winter were also identified.

More problems were identified. A constant fractional difference between the satellite and the ground-based data suggests an ozone coefficient error. Also jumps in the difference usually will be mirrored in the standard lamp values (these can be used to make corrections). Other causes include the differences in the temperature dependence of the cross-sections assumed for ground and satellite, the lack of a stray light correction for Dobson's and single Brewers for measurements with large slant column amounts (>1000 DU) and different assumptions in the retrieval algorithms for the various measurements (e.g.: airmass, ozone layer height).

Finally a list of recommendations were submitted and accepted by the SAG Ozone, which are:

1. Letter to be sent to all stations.
2. Includes results of the analyses.
3. Short report from the T.P. advising on the data quality and possible remedial steps to take.
4. Call for re-analysis & re-submission.
5. A list of experts to contact for help if required.
6. A strong statement that changes in the record NOT be made simply to make the station agree with the satellite! Corroborative evidence from the station records is required.

A list of issues was also assembled:

1. Tables of issues are identified for Dobson and Brewer.
2. Spreadsheets were developed identifying issues by number for each station.
3. A database is being set up so that individual letters to each station can be automatically produced and sent out with the analysis results included for individual stations.

A final comment: the outcome of a calibration should be that the entire data record should be reprocessed. For example, a new calibration may indicate that a previous calibration may require removal in order to improve the data record quality.

Question 1: Are there step functions in the satellite data? Answer: Since the satellite data are an ensemble this may not be apparent. The assumption is if a step function occurs, it will be present for all data sets.

Question 2: How true is that assumption? Answer: the ensemble makes this assumption reasonable.

6.5 Ozone Absolute Langley Calibration (A. Redondas)

A. Redondas of INM, Spain presented a brief update and results from work in regression analysis of the reference instruments of the RBCC-E triad, including the status. The instrument information is given in Table 5.

The Langley regression method was presented. The measurements are split into AM and PM and within an air-mass range of 1.15-1.5 and 2.5-3.0 as specified from the Dobson operator manual (Komyr-1988). The ozone must be constant during the measurement period and it requires stable atmospheric conditions, without haze, smoke or dust. Two Dobson units are used for the standard deviation.
Table 5: Brewer instruments at RBCC-E.

<table>
<thead>
<tr>
<th>Brewer #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#157</td>
<td>Reference, stable, Temperature stabilization in progress</td>
</tr>
<tr>
<td>#183</td>
<td>Develop and Test, Seriously affected by Delta Tropical Storm (November 2005).</td>
</tr>
<tr>
<td></td>
<td>Repaired (May 2006)</td>
</tr>
<tr>
<td>#185</td>
<td>Travelling standard, Travel to SAUNA I/II campaign, return without changes</td>
</tr>
<tr>
<td>#033</td>
<td>MK-II installed at sea level</td>
</tr>
</tbody>
</table>

The DS measurements analysed were collected during Normal routine operation. The MS9 Calculation from the raw counts with an ability to introduce new instrument constants. The morning and afternoon measurements were analyzed independently. The air mass calculation was done using the Brewer software. Analysis dataset included:

- Air mass 1.15-4.5.
- Nº data points > 25.
- All weather conditions.
- Routine DS observations.

The regression Method used was the Ordinary Least Square (OLS) and the ETC selection was:

- nº data points    > 50
- R-square        > 0.9995
- Ozone std       < 2.0 UD
- Data are binned to avoid having to many points in lower air mass.

A time series from the travelling standard instrument (BR#157) was presented, indicting the various calibrations and the ETC Langley calibration record. Similar summaries were given for instruments BR#183 and BR#185 respectively. A tropical storm caused damage to one of the triad instruments. A summary plot of the triad status based on the Langley calibration is given in Figure 8.

![RBCC-E triad after #183 reparation](image)

Figure 8: The RBCC-E Brewer Triad.
When you view the ozone along an oblique angle you average out some of this ozone variability that appears when you view the layer vertically. One sometimes has a simple view that the ozone variability is small in the tropics, but this based on chemistry and does not include the effects of dynamics.

7. SESSION IV: OTHER METHODS

7.1 Brewer Algorithm Sensitivity (A. Rendondas)

Rendondas updated the Brewer algorithms in use at RBCC-E and described the various issues related to the use of these algorithms. Total ozone from a single wavelength requires the Aerosol Optical Depth (AOD). Total ozone from four wavelengths reduces the sensitivity by 1% (from 3% to 2%).

Systematic errors were then discussed and the weighted ozone cross-sections were shown including a discussion of the weighted molecular cross-sections and effective ozone height. The role of instrumental stray light and scattered radiation effects were also presented. In summary, the systematic errors are discussed in the conclusions.

As a result of the SAUNA campaign, 'Effective ozone location', LO3EFF, was added to the output data. LO3EFF gives the latitude and longitude of the geographical location, where the direct beam crosses the effective ozone height. The distance of LO3EFF to the measurement site is smaller (but not zero!) for zenith or nadir measurement techniques. A plot of the LO3EFF is given in Figure 9.

![Figure 9: The Effective Ozone Location (LO3EFF) plotted as latitude versus longitude.](image)

In conclusion:

1. A best Brewer total ozone data series for every minute was constructed combining the operational data from all 5 instruments.
2. There were no unexplained outliers in the whole dataset.
3. The double and single Brewers showed very small systematic differences (<0.2%).
4. Brewer #171 is slightly noisier than the other Brewers. Part of it may be explained by the less frequent wavelength calibrations during SAUNA.
5. The operational cloud screening usually works well. Sometimes under large SZA/O3SC and/or large cloud-aerosol optical depth conditions a cloud-affected data point is not filtered.

6. An empirical instrument-stray-light correction for single Brewers was determined and confirmed with Izana data.

The resulting recommendations are:

1. An empirical instrument-stray-light correction for single Brewers was determined. This may be used to correct single Brewer data worldwide.
2. The operational cloud screening usually works well, but it is useful to include the measured intensity (AOD) in the cloud screening when available.
3. The synchronized Brewer schedule used during SAUNA produced a high number of simultaneous measurements. This is recommended as a good approach for future campaigns.
4. When comparing to other instruments the effective ozone location LO3EFF must be considered. It is suggested that when comparing the ground-based direct sun data to satellite retrievals, it should be done for the pixel closest to LEFFO3 instead of the pixel closest to the ground measurement site itself. This implies of course that also the “effective” satellite pixel and not the “geographical” satellite pixel must be used.

Redondas also gave a brief overview of the SAUNA campaign and listed the participants and the instruments involved. Some daily data outliers were identified. Some comparisons between the single and double Brewers were presented comparing the stray light. Then an examination of synchronous data was given. A comparison of the double Brewers then a similar comparison was done for the single Brewers. Thus, a SAUNA reference set was built.

The single Brewer stray light effect was plotted for various instruments. McElroy commented that a model which retrieves a stray light parameter in it is better then simply a two parameter fit model. The single Brewers are corrected and compared again with the doubles. Then the effective ozone location effects were discussed. In conclusion, some recommendations were made.

Question: How important is the stray light correction for single Brewers at mid-latitudes? Answer: If you are under 1000 DU in slant column the correction is small. Fioletov commented that depending on the time of year this correction may be small, but could affect the trend.

7.2 Validation of the Method for Retrieving Aerosol Optical Depth Obtained with the Langley Plot Method using a Brewer (A. Cheymol)

A. Cheymol from the Royal Meteorological Institute of Belgium presented a study of a retrieval method examining the impact of the neutral density filters on Aerosol Optical Depth (AOD) measurements and the validation of the AOD between a Brewer and a sunphotometer. Included were comparisons between different Brewer instruments at the same location. The AOD was calculated for three sites in Europe (Norrkoping, Sweden, Uccle, Belgium and Arosa/Davos, Switzerland).

Direct Sun (DS) measurements made with a Brewer Instrument at 320 nm analyzed with a Langley analysis to retrieve the AOD was done for Figure 10 and shows the effect of filters on the AOD. Figure 11 shows the comparison of the sunphotometer with the Brewer data at Arosa, Switzerland. Next, a comparison of the AOD on the single versus double Brewers from quasi-simultaneous measurements (<3 minutes difference in time) was done and a summary of the comparisons are listed in Table 6 showing the correlation coefficients.
The selection of clear days for the Langley Plot Method looked at ozone standard deviation for individual DS measurements < 2.5 DU, Δz_a per day ≥ 20°, the number of good data per day ≥ 50, the distance between each point and the regression line < 4 (Y unit) and finally daily mean absolute deviation from the regression line < 0.055 (Y units).

![Figure 10: Filter impacts on the AOD.](image)

\[
\begin{align*}
&c = 0.87 \\
&b = 0.80 \pm 0.011 \\
&a = -0.08 \pm 0.004
\end{align*}
\]

![Figure 11: A comparison of the Brewer (BR#040) with the sunphotometer at Arosa, Switzerland.](image)

\[
\begin{align*}
&c = 0.98 \\
&b = 0.85 \pm 0.004 \\
&a = 0.02 \pm 0.0014
\end{align*}
\]

![Table 6: Comparison of the single and double Brewers at Arosa and Uccle.](image)

<table>
<thead>
<tr>
<th>Brewer</th>
<th>016</th>
<th>040</th>
<th>072</th>
</tr>
</thead>
<tbody>
<tr>
<td>178</td>
<td>0.98</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.02</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>156</td>
<td></td>
<td>0.94</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.03</td>
<td>-0.04</td>
</tr>
<tr>
<td>072</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.98</td>
<td>-0.02</td>
</tr>
</tbody>
</table>
In conclusion,

1. Important role of the filter values of the Brewer spectrophotometer on the accuracy of AOD
   a. high level of confidence of the method used to retrieve the AOD:
   b. correlation coefficient > 0.94
   c. slope ~ 1
2. Intercept is negligible.
3. Validation of the Langley plot method with a comparison between Brewer spectrophotometer and a sunphotometer.

Question 1: Why did you restrict the study to just to 320nm?  Answer: It is the wavelength closest to that of the sunphotometer.  Comment: with the CIMEL, the angstrom coefficient can be used to model the difference in wavelength.

Question 2: Did you assume an angstrom coefficient?  Answer: Yes.

Question 3: What is the relative field of view of the sunphotometer?  Answer: The CIMEL is about 2 degrees, so perhaps it is close to this value.

7.3 Kipp and Zonen Updates (B. Dieterink)

B. Dieterink of Kipp and Zonen, The Netherlands gave an overview the changes at Kipp and Zonen since the last Brewer meeting at Delft in June 2005.

- New facility, July 2006.
- New internet provider and servers.
- Opening of Singapore office serving South East Asia.
- Acquisition of Mierij Meteo Nederland BV, November 2006.
- New products: CMP series, CNR2, Uviator software.
- Staff expansion
  - Manufacturing
  - Marketing Communications
  - Finance and Administration
  - HRM

A move to a new facility (Delfttechpark) was a primary difference along with new branch office openings. The facility is shown in Figure 12.

Figure 12:  Delfttechpark, the new location for Kipp and Zonen.
Updates were given on the manufacturing of the most current Brewer instruments: BR#190, BR#191 and BR#192 that were delivered to Environment Canada. The Brewer manufacturing maintains a “build” quality control which includes CE certification and other international safety standards. These standards have become an issue which has presented a new challenge. Also the quality of the electronics and PMT were discussed. Procedures processing includes Manuals (MKIII single board: updated when necessary and the MKII, IV and III multi board are not maintained anymore) and other Technical Documentation added when available.

A new web site is being developed to serve as a Brewer user’s group site, an on-line forum and a software agreement was presented that indicates that IOS Inc. is now recognised as the source for software utilities and updates.

Question: Is there any possibility of upgrading the operating software system? Answer: A session that illustrates some of the new code will be presented later in this workshop. T. Kosekla mentioned that earlier components of the Brewer may be unsafe such as ungrounded wires or metal switches, so users beware! Dieterink updated the group on many of the safety upgrades made to achieve a standard set of certified modifications.

7.4 The 6th Brewer Sub-Committee Meeting

The 6th Brewer Sub-committee meeting was held as a special session during a break in the poster session. Approximately 25 people were in attendance. For a copy of the report, refer to the linkable meeting Agenda on the meeting web site or visit the WOUDC-BDMS ftp site.

Clickable Meeting Agenda:  http://www.woudc.org/meetings/index_e.html
Brewer Sub-committee Reports Link:  http://www.woudc.org/data/bdms/reports_e.html
Ftp access to the 2007 report:

8. SESSION V: KEYNOTE SPEAKER – (J. Shanklin, British Antarctic Survey)

J. Shanklin of the British Antarctic Survey (BAS), U.K. gave a retrospective of ozone studies and the science conducted at several stations located on or near the Antarctic continent. There used to be Dobson instrument located at King Edward Point, near the Falkland Islands and one remains at Halley which is located on a floating ice shelf, about 30 m.a.s.l.. Halley has been in operation since 1956. There are persistent problems with snow build-up resulting in station buildings being buried over time. Recent structures were built on adjustable stilts that can be raised about 1 metre per year. Figure 13a,b depicts the original structures and the current one. Newer designs will have the station on the stilts that have skis that can allow for snow compaction in order to maintain the consistent surface position. In addition, the station is located 15km inland, but there are concerns a large section of the ice may break away (as an ice shelf) taking the station with it.

Figure 13a: Original structures at Halley Station.
Figure 13b: Current building design featuring adjustable stilts.
The Halley station was named after the “comet scientist” who was also interested in the aura, haloes, rainbows, tides and magnetic fields. The Halley station is also home to the emperor penguins one of the oldest groups of the birds. The other station involved in the discovery of the ozone hole was Faraday, now called Verdansky (both Faraday and Verdansky were notable physicists). Each base has a magistrate, plus a postal service and there are no officially recognised countries as the Antarctica is used for science and one must have its host country’s permission to go there. Other locations where Dobson instruments are located are: South Georgia Island, Halley Bay, Faraday (Verdansky) and King Edward Point. Joseph Farman, himself and Brian Gardner have been the primary investigators for the ozone science at BAS.

Shanklin emphasised that the Dobson instrument contributed to the discovery of the ozone “hole” because the BAS staff chose to use the same instrument in the same way since its inception in 1956. This contrasted with satellite group that was turning instruments around more quickly, but was not being calibrated with the same degree of certainty. This was done because the BAS staff wanted to confirm that the original instrument was operating properly and thus brought down another Dobson in order to confirm the status of the instrument. Calibrations are done in place using the Langley method. For historical purposes, the data were recorded on forms, but often the operators would make small mistakes such as writing time, both local and GMT. He joked that the local solar time was not to be confused with the “kitchen” time. If you write down a number there are also errors like 101.2 can become 111.2 for some strange reason, perhaps simple human nature.

The presentation then shifted to a general discussion of various scientific studies. For example, by observing the bubbles in ice cores, one can determine the CH$_4$ and CO$_2$ amounts and thus derive the temperature. An example of the ice recession was shown, illustrating the amount of “land” lost in the last decade as given by Figure 14. Shanklin recalled that the use of aerosol cans and the Concorde aircraft issues were topical around the time he graduated and thus began to examine and compare the ozone data. To his eye, he saw some trends, but Farman thought that the spring time vortex was the main driver, thus capturing more or less, these subtle downward trends could explain these low values. Shanklin wrote a report prior to the release of the landmark paper (Large losses of total ozone in Antarctica reveal seasonal ClO$_x$ / NO$_x$ interaction, by F.C. Farman, B.G. Gardner and J.D. Shanklin) explaining the decline. An original graph of the ozone plot from Halley Bay is given in Figure 15. This lead the Americans back to their satellite data. He recalled having had already written to the NASA Wallops team asking if the satellite data could confirm this ozone loss. A reply letter came back saying that this work had been discontinued. Later, the NASA team re-examined the entire continent which gave a much more global view of the ozone field.

Figure 14: Loss of ice shelves.

Figure 15: Original plot of the ozone loss in Antarctica.
Daily routines at the stations include radiosonde launches, which show a substantial correlation between the temperature and the ozone decline. For special research, ozonesondes are launched; even though other stations perform these launches regularly, the BAS only flies ozonesondes for special purposes. Shanklin commented that “we are going to have to go a long way into the future in order to get a picture that ozone is recovering”. He also emphasised that the space-based components are becoming the really critical systems but there are two aspects to the science picture. One, the satellite systems provide the global view, especially for the day to day studies, but there is also a need for ground-based systems to give reliable data that can be used for comparison and sometimes even calibration. The space-based systems are susceptible to higher level UV and thus greater degradation. His conclusion is that is why ground-based systems (which are better for long-term studies) discovered the “ozone hole”. It was also noted that the Halley Bay station is fortuitously positioned to be in the middle of the hole that the American station at the Antarctica did not see.

A greater volume of space is available for the formation of stratospheric clouds because of warming at the surface and colder upper air temperatures (<-78C), thus the photo-destruction of ozone can be up to 1% per day. The Antarctic continent has one of the highest doses for UV exposure, only 5 minutes at the ozone hole peak, can cause sunburn. A minimum of SPF 30 sun block (sun screen) is required. Since ozone is a radiative, reactive gas, it also absorbs energy. There is a positive feedback, this process is contributing to the expansion of the ozone hole. Volcanic eruptions also contribute substantially to the increase in the aerosol. Increases in aerosols, observed over Antarctica can contribute to the increase in CFC chemistry which adds to the destruction of ozone. For example, in 1992 after the Mount Pintatubo eruption, the lowest ozone levels were observed.

In conclusion, the treaties (Vienna Convention and Montreal Protocol) that have lead to limited production of CFCs have been successful. The only state that did not sign the treaties is the Vatican state. The chlorine levels are diminishing so it is working, but in some cases, the CFCs are only “gently” being reduced. The ozone hole is a symptom of the health of the planet. Shanklin contends that we need to look more broadly for indicators such as biodiversity indicators, severe congestion on global roadways, socio-economic indicators such as the increase in population, also illustrate the concept, if you only treat the symptom and not the underlying cause, you will not repair the problem, which is not a sustainable position.

A question concerning the recent data was asked. Shanklin referred to how his latest data set from the Antarctic spring (September-October 2006) did not show the low ozone, but once he did a re-analysis in March 2007, the values went from 112 to 97 DU, but at that point, he felt it was too late to make any form of an announcement. He also emphasised that the direct sun measurements are “unequivocal”… everything thing is referenced to it.

9. SESSION VI: UV STUDIES, CALIBRATIONS AND DATA ANALYSIS

9.1 Applying SL Corrections to ETC for DS Observations (V. Savastiouk)

V. Savastiouk of Environment Canada gave a presentation on the Standard Lamp (SL) corrections to ETC values for the DS observations. The rationale for this study was three fold:

1. Need a way to track Brewer’s spectral sensitivity changes.
2. Need a way to apply a correction for these changes to ‘improve’ calculated ozone values.
3. Will assume that RS, DT, HG, temperature coefficients and instrument pointing are all ok.

The SL test was used as a mechanism for tracking changes. The first step is to know what the instrument is measuring. An argument for using the SL ratios is that the R6 for DS observations and for SL observations is calculated in the same way. It does not depend on the
overall brightness of the source and it has the same “units”. An assumption must be made that the DSR6 and SLR6 change the same way when the instrument’s spectral sensitivity changes. Thus, using this assumption:

The **ETC-R6** will be constant, thus

\[ \text{ETC-R6}_{\text{cal}} = \text{ETC^*-R6} \]

or

\[ \text{ETC^*} = \text{ETC} + (R6 - R6_{\text{cal}}) \]

The data evolution is depicted in Figure 16 and illustrates an important point, know your R6! The ETC and R6 at the time of the last calibration may lead one to make adjustments. For example, if the ETCs have been adjusted then use the new ETC/R6 pair as a reference. This varies from a replacement which is done if the lamp was replaced and the R6 has changed then use the new R6 and the (adjusted) ETC at the time of the replacement as a reference (i.e. \( \text{ETC^*} = \text{ETC} + (R6 - R6_{\text{cal}}) \)). Further, if calibrations are done in the same way, using the ETC and SL ratio R6 cal, then the data evolution given in Figure 17 applies.

![Data evolution](data-evolution.png)  
**Figure 16:** Data evolution for R6 ratios.

![Data evolution](data-evolution-cal.png)  
**Figure 17:** Data evolution for R6 ratios applied to a calibration.
How does one know if the current calibration is correct? If ETC-R6cal=ETCNewcal-R6Newcal is true, then everything is ok and no further action is required. However, it may take some time to determine whether this is true. To assist in the process examine the long-term record or satellite data. If you determine the calibration is “bad”, you must ignore it and go back to the previous one. If the calibration is fine, the following correction does a good job to the first order.

$$ETC(t) = ETC + (R6 - R6cal) + (R6cal - R6Newcal - ETC + ETCNewCal) \ast t / T$$

Where T is the time between calibrations and t is the time since the previous calibration. This works, assuming that the changes are from slowly changing factors.

In conclusion, the “final” SL correction can only be done for a period between two calibrations. One must apply similar care to using the temperature coefficients correction, Dead Time (DT) or any other corrections. The only way you can say the SL is final is to wait until you do your next calibration!

Question 1: Does moving a instrument to a new station location cause a problem for calibrations? Answer: A second or third order effect of the refractive indices of the prism and change in pressure may be a problem, the dispersion changes. Savastiouk made a final remark that the lamp responds quite a bit during the calibration process with the activity and thus one must be vigilant in checking the R6 values as they may change slightly during the whole process, and so to be safe, wait a few weeks.

It is important to re-calculate the data as well after the calibration to confirm that it is authentic.

Question 2: Do you know why the Hong Kong data are so anomalous? Answer: It appears that the “new” filter replacement may have caused it (possibly due to humidity).

9.2 SAUNA II Preliminary Results (T. Koskela)

T. Koskela from the Finnish Meteorological Institute began with the SAUNA II goals, which are to measure reliably, the ozone hole when the sun angle is low and the available radiation is also low. Table 7 provides a list of instruments involved in the SAUNA II campaign.

<table>
<thead>
<tr>
<th>Brewer serial number</th>
<th>Model</th>
<th>Operating Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brewer #037</td>
<td>MK-II Single</td>
<td>FMI</td>
</tr>
<tr>
<td>Brewer #039</td>
<td>MKV Single</td>
<td>MSC-R</td>
</tr>
<tr>
<td>Brewer #071</td>
<td>MK-IV Single</td>
<td>MSC-4</td>
</tr>
<tr>
<td>Brewer #085</td>
<td>MK-III Double</td>
<td>MSC-D</td>
</tr>
<tr>
<td>Brewer #107</td>
<td>MK-III Double</td>
<td>FMI (2 weeks)</td>
</tr>
<tr>
<td>Brewer #185</td>
<td>MK-III Double</td>
<td>IZO</td>
</tr>
</tbody>
</table>

Transportation of the instruments is viewed as an important aspect. If an instrument is transported by air, it usually requires the purchase of an extra seat to ensure stability during transport. Most instruments were transported by vehicle and cargo. The key points of the campaign were:

- The campaign started in February: high solar zenith angles.
- No Dobson instruments were included this time.
- Blind inter-comparison for the Brewers, the configuration and data were sent in real-time to www.iberonesia.net.
- More attention to zenith sky, focused sun and ozone global UV port measurements.
- The first Moon measurements inter-comparison.
• DS often not available for weeks at high latitude sites.
• Instruments calibrated using DS only.
• Other measurement types assumed to be OK.

The preliminary data processing path was presented and the flagging techniques were discussed. The data processing involved the following limits:

• SL correction for #107 only.
• DS: S.D. < 2.5, am < 6.0.
• FZ: S.D. < 2.5, am < 10.0.
• FM: S.D. < 10.0, am < 3.7 (5.7 for #107).

And the data flagging:

• Good if abs(SO$_2$) < 5.
• Suspect if 25 < abs(SO$_2$) > 5.
• Reject if abs(SO$_2$) > 25.
• Reject if suspect in SO$_2$ and visually an outlier in ozone.

Results from the various instruments were shown for the various types of observation. The comparison of the DS to FM are shown in Figure 18a,b respectively. Finally the results of the campaign were shown what happens once there was little or no light available.

Figure 18a: Preliminary results for DS observations.

Figure 18b: Preliminary results for FM observations.

Preliminary results and conclusions are:

• All agree roughly normally in ds
• In fz the values range ~5%
• In fm the values range ~10%
• Both fz and fm may show systematic instrumental differences
• No explanation to this so far
• No difference in calibration trace (#017)
• Even between similar instrument types
• No change in transport
• Sensitivity of PMT at very low signals?
• Differences in foreoptics, e.g. field of view (FOV) ??
• Reject fm in data processing?
• Reject fz, too??
Comment: You mentioned the FOV. There seems to be two, 1.5 and 2.7 which could lead to bigger problems. A suggestion is to characterise the instruments for the two FOVs. This will affect FS but what about FM? The lesson is to have a routine available to test each instrument.

9.3 Total Ozone and UV Radiation Measurement Programme in the Italian Air Force Met Service Background Air Pollution Monitoring Network (E. Vuerich)

E. Vuerich from the Italian Air Force Meteorological Service presented a summary of the general situation of the ozone and UV monitoring programme. The central office is based at Vigne di Valle and some of the activities were described such as:

- A 100 year old Observatory.
- Experimentation centre of meteorological instrumentation.
- Site for WMO Field Rainfall Intensity Inter-comparison.
- Quality assurance of measured data from Met Service Network with reference sensors.
- Methodology for old/new instruments control, monitoring and verification.
- Special measurements: air pollution monitoring + global irradiance + UVB irradiance + precipitation chemistry.

A historical time series of the Dobson from Vigne di Valle was discussed and is given in Figure 19.

![Figure 19: Long-term time series of the ozone record from Vigne di Valle, Italy.](image)

The Brewer instrument was brought on line to be added to the data record. Additional general updates were summarised:

- Situation in spring 2006 after some years of operational difficulties: B063 and D048 the only spectrophotometers working.
- Summer 2007: the ITAF-MS monitoring “FORCE” will be composed of 7 spectrophotometers fully operational and calibrated (3 Dobsons, 4 Brewers) + 1 Dobson in refurbishment (RDCC) + 1 ozone sounding station.
- In some cases measurements continued to be performed even if no data were sent to WOUDC (it was necessary to solve organization internal problems, such as lack of expert technicians, loss of know-how, ITAF changes etc.).
Specific “domestic” files are in use to evaluate the optical-mechanical status of working Brewers.

In conclusion, future challenges were outlined as:

- To contribute again to the world-wide ozone and UV monitoring programme, becoming a reliable monitoring country in the middle of Mediterranean Sea.
- To re-build historical series (e.g. applying the right transfer function for Dobson-Brewer replacement in Vigna di Valle and obtain the 1958-2007 time series).
- To fill the data gaps and re-process data.
- To maintain TRACEABILITY (14th CIMO strong recommendation).
- To perform measurement integration according to GAW n.149: Brewer ozone, Dobson ozone, ang Ozone soundings.
- To perform UV calibration on operational Brewers (scheduled for 2008) in order to retrieve UV index (human health; national warnings).
- To activate Umkehr processing, NO$_2$ and AOD routine measurements (scientific and research purposes, background air pollution monitoring).
- To become a reliable NO$_2$, SO$_2$, AOD routine monitoring country in the middle of Mediterranean Sea.

**Question 1:** Have you already performed UV-B measurements with the Brewer in past years? **Answer:** Yes. We did not stop, but we have had problems that we needed to control and to have calibrations to produce reliable data.

**Question 2:** Do you still have umkehr measurements from the historical Dobson? **Answer:** No. Unfortunately, we presently do not have the personnel to make these measurements. **Comment:** The data are being made available in NRT (CREX/BUFR) on the GTS, which was decided by the IAF as its contribution to the WMO.

10. **SESSION VII: SOFTWARE AND ANALYSIS TECHNIQUES**

10.1 **Brief RBCC-E Campaign Update (A. Rendondas)**

Redondas gave a brief overview of the RBCC-Europe and its activities. The slides are unavailable at this time.

10.2 **Brewer Health Diagnostic Database (V. Savastiouk)**

Savastiouk outlined the rationale and purpose for the development of this database namely by asking the question: How can we tell that a Brewer is OK? The answer is to examine the following routines: SL, DT, RS, HP, HG (UV?, DS?). Can diagnostics be done without additional software? The answer is yes, but it is complicated by the difficulty of searching out historic data, decision-making is primarily subjective and the exercise is time consuming when dealing with many Brewer instruments.

The database approach used mostly open source software with the web code done in PHP.

- Apache web-server.
- PHP interpreter.
- MySQL database engine.
- GnuPlot plotting package.
- Scripting language allows to change the programme quickly when needed.
Using this database approach, one advantage is the preparation of reports about the data that have been collected. For example:

- Identify outliers easily.
- Keep track of SL and other tests.
- Start putting some intelligence into the diagnostics by analyzing several type of tests/observations together.
  - What leads to the HG failure?
  - Did we forget to do HP before HG on a MKIII?

The current database organisation has known tags which have their columns of named data. For unknown tags columns have “field_1” type of names and unknown or unrecognized records are put in a separate table. Recognized, but erroneous (wrong formatting) records are put in normal tables that are “marked”. Finally, a tutorial, “hands-on” session to demonstrate this software was provided later in the workshop.

10.3 Brewer Ozone and UV Processing and Analysis Software (V. Fioletov)

Fioletov outlined the rationale and purpose for the development of this analysis software. It is presently used by Environment Canada staff and uses open source C++ compilers. The software can run as a schedule task and makes use of the command prompt if necessary and will process both B and UV file types. Instruction on the setup and use of the software were also reported.

The software outputs daily ozone values and individual measurements in ExtCSV format (for submission to the WOUDC) and also will generates graph and plot images that can be accessed by a browser. Ozone and UV values are calculated from raw counts including additional quality control features.

The UV algorithm includes:
- Responsivity interpolation
- Stray light correction
- Total ozone and SO₂ calculation from spectral UV
- “Spikes” correction
- HG control (from B-files)
- Data quality flags
- Angular response correction (based on Brewer #14 properties)

The Total ozone algorithm includes:
- All “standard” steps for ozone processing
- Additional quality control steps
- Works directly with calibration files
- Does SL-test correction for ozone
- Uses HG tests for quality control
- “Ozone from UV” is included in the ozone output files

Output data files include:

1. Daily ozone values in ExtCSV format for WOUDC \TotalOzone directory
2. Individual ozone measurements (DS, ZS, and UV) in ExtCSV format for WOUDC \TotalOzoneObs directory
3. Spectral UV data in ExtCSV format for WOUDC \Spectral directory
4. Daily summary UV data in ExtCSV format for WOUDC Summaries\Spectral_UV directory

A sample of the various output images are depicted in Figure 20.
Figure 20: Output products from the Brewer analysis software.

Future versions of the software will include:

1. Accounts for stray light in DS and ZS ozone.
2. Use temperature or ozone profile information to derive column ozone.
3. Calculate ZS coefficients.
5. Correct UV data for temperature dependence.
6. Correct UV data for small wavelength shifts.

To download a copy of the software, go to FTP to ftp://es-ee.tor.ec.gc.ca, Username: bps, password: bps*. Finally, a tutorial, "hands-on" session to demonstrate this software was provided later in the workshop.

10.4 Brewer Software Development (J. Rimmer)

J. Rimmer of the University of Manchester outlined the rationale and purpose for the development of his Brewer operational software. The current software was discussed by listing some of the features and attributes.

- DOS based
- Non-graphical
- USB-Serial adaptor problems
- Limited peripheral functionality
- BrewCmd won’t run on OS above Win98
- Stable
- Reliable
- Well tested
- Easy to merge custom .rtn routines
- Well understood by the experts

A wish list was shown indicating the types of features or elements that would be desired.

- Brewer control and BrewCmd software to run on modern machines with modern OS.
- No USB-Serial adaptor problems.
- Graphical user interface.
- Easy to write new routines.
- Extra peripheral functionality.
- Incorporate BrewCmd functions.

And other items in progress are

- Win32 based control software.
- On screen graphical output.
- No problems with USB-Serial adaptors.
- Runs with existing config files and innn directory.
- Familiar operation.

A sample interface was shown illustrating the graphical features and menus for the various routines, all displayed in a multi-faceted GUI as given in Figure 21.

The source code was written in Delphi 5 in order to keep it open and friendly. There are error trapping, abort, motor restore etc. features, all in one procedure. Control functions are ready to call and to add any new routine requires only three lines of code in the Brewer control unit. Further development plans include:

- Auto ftp set up.
- Internet time server query.
- Send email if a problem.
- Add BrewCmd functions.

Figure 21: The University of Manchester, operational Brewer software GUI.

A tutorial, “hands-on” session to demonstrate this software was provided later in the workshop.

Question 1: When you are only running one brewer and not several in parallel, how can you tell that what you are running is actually right? Answer: I can’t say for sure. Likely this requires a bit more observation, but it is on-going. Further Comment: It is a move toward a compiled language which is part the way there.
Question 2: If you have a fixed pressure or do you adjust it? Answer: it can be adjusted, but generally it is left alone.

Question 3: Will it run on the next version of Microsoft O/S software? Answer: this is a problem that many will face.

10.5 WOUDC and BDMS (E. Hare)

E. Hare of Environment Canada gave an overview of the current status of the WOUDC and the BDMS. All the reports were generated from the web forms available from both of the web sites (www.woudc.org/data) and (www.woudc.org/data/bdms). Including updates resulting from the Technical Panel and SAG Ozone group meetings that were held in April 2007 in Tenerife Spain. Highlights of the meeting are given in the report by C.T. McElroy.

Several issues were raised:

1. Data file disclaimer header – from World Data Centre meeting in Dübendorf, Switzerland, March 2007 it will appear within ALL data files.
2. Total ozone tables & new variable additions (Re: Savastiouk).
3. A collaborative effort between IOS and WOUDC for Web based calibration information.

Hare also emphasised the importance of the “Data Passport”, that it is a fundamental descriptor of many aspects of data quality, written by the data originators or principal investigators (PI). Some key aspects of a Data Passport are:

1. How data are measured and collected.
2. Network (site/platform) information and updates on any relevant changes such as obstructions etc. (where applicable).
3. Compliance with SOP’s and other standards.
5. Contact information.

An example of the effectiveness of data re-evaluation and the importance to the data quality was shown. Refer to Figure 22.

Figure 22: Effect of data re-evaluation on data quality.
Finally, the WOUDC is working closely with IOS Inc. to share information about calibration data across both web sites. It was also emphasized that the WOUDC values the close collaboration with each data originator and his/her respective agency/institute.

11. SESSION VIII: DISCUSSION AND RECOMMENDATIONS (C.T. McElroy)

Inadequate co-location of satellite versus ground-based (coincident with LAN) observations was discussed and suggestions for locations and the definition the "corners of the satellite footprint" was put forth to the group to consider.

Question: Is there a proposal to have at least 3 points per day, and to submit these data? Answer: All we need is the time and air mass. Some redundancy on what is collected is useful to reconstruct exactly what measurement was being made. A further comment was made and stressed the importance that the longer an instrument stays in place, the better.

There was a brief discussion regarding the instruments from developing nations and the need for regular calibrations.

Recommendation 1:

Recommend that instruments get together for calibrations for both South America (possibly at Puentas Arenos, Chile) and India. There should be a call letter from WMO inviting participants and providing for travel support, which would include an IOS visit to perform the calibration of these instruments. Note: David Wardle commented to the group on the effectiveness of the travelling standard as a calibration method.

Results and action plan from the Technical Panel report were adopted and no discussion was required.

Recommendation 2:

Adopt the recommendations as specified by the WMO Technical Panel report from the Tenerife, Spain meeting, April 2007.

There was a brief discussion about tracking the users of the data and the different data types that are being accessed through the WOUDC and BDMS.

Recommendation 3:

Recommend that the WOUDC provide data usage tracking statistics in the form of a report (perhaps annually).
12. POSTER SESSIONS - ABSTRACTS

Retrieval of AODs from Brewer Direct Sun Measurements: Preliminary Results for Madrid during 2006
A. Portillo, B. Navascués, M. López, D. Gil, and A. Cansado
National Institute of Meteorology, Spain

Abstract: Brewer spectrophotometers located in La Coruña, Madrid, Murcia, Zaragoza, Izaña (Tenerife Island), Santa Cruz de Tenerife, and El Arenosillo (property of INTA, the Spanish Public Research Organization specialized in Aerospace Research and Technology Development). So far, these instruments have been used for the continuous monitoring of atmospheric total column ozone, total column sulphur dioxide, and spectral intensity profiles of ultraviolet radiation since its installation, between 1992 and 2000.

With the aim of extending the routine measurements to the characterisation of aerosol properties, a methodology to obtain aerosol optical depth (AOD) in UV range, using the direct sun (DS) measurements from Brewer instruments, based on the Beer-Lambert-Bouger law, has been recently developed. It includes not only the preliminary data reduction needed to process the raw-photon-count measured by the instrument and determine ozone and sulphur dioxide column amounts (converting counts, and computing ratios), but also a complete method to estimate the absolute extraterrestrial constant at each of the five operational wavelengths (306, 310, 313, 316, and 320 nm). It consists on Langley regression of the measurements previously filtered by a cloud-screening procedure, based on the Aerosol Robotic Network (AERONET) standard methodology for this purpose.

We describe herein the implemented algorithm and its application to the Brewer data at Madrid (latitude 40.45° N, longitude 3.71° W) during 2006, as a case of study. As part of the validation of the developed algorithm, the obtained AODs have been compared with those derived by a CIMEL sun-photometer located at the same place, during the summer of 2006.

Back-trajectories over Madrid have been also calculated during this period using the FLEXTRA model, installed on the computers at the INM headquarter. The analysis fields from the INM Numerical Weather Prediction operational suite, HIRLAM, have been used as input to FLEXTRA model. The calculated back-trajectories help to explain the observed day-to-day variability in the retrieved AOD

Recalculation of 11 years of Total Ozone of Brewer spectrophotometer #115
K. S. Lam1, V. Savastiouk2, W.Y. Fung1, T.K. Chan1, K. Lamb2
1The Hong Kong Polytechnic University, Hong Kong
2International Ozone Services Inc., Canada

Abstract: The aim of this study was the recalculation of Brewer’s total ozone and to conduct a trend analysis of ozone recovery in Hong Kong. Two processes were combined, one being a linear interpolation of the calibration results and the second, a three-day running average of daily changes in SLR5/SLR6 values. The recalculated Brewer #115 data agrees very well with the TOMS satellite data, and the Chengkung Brewer #061 data. No ozone depletion was observed over Hong Kong during the study period of January 1995 to December 2005. Data used in this study are archived at the WOUDC.
**Diffuse, Reflected and Global Spectral UV Observations using Brewer Spectrophotometers at Tsukuba, Japan.**

*M. Ito*

*Japan Meteorological Agency*

**Abstract:** A modified Brewer spectrophotometer to observe reflected UV radiation on the ground surface and an automated shadow unit to observe diffuse UV radiation in the sky, together with the calibration and the monitoring methods of instrument responsivity, were completed at the Aerological Observatory in Tsukuba (Ito: 2004, 2005a, 2005b, 2006). In this paper, the results of reflected and diffuse spectral UV measurements carried out from December 2003 to December 2006 and from August 2005 to December 2006, respectively, are presented compared with global UV and solar radiation data. The instruments are shown in Photos.1 to 5 and Table 2. The symbols are: RFuv: reflected UV, DFuv: diffuse UV, GLuv: global UV, RFsolar: reflected solar, DFSolar: diffuse solar, GLsolar: global solar, RRFuv: reflectivity RFuv/GLuv, RDFuv: diffusibility (diffuse irradiance ratio) DFuv/GLuv, RRFsolar: reflectivity RFsolar/GLsolar, and RDFsolar: diffusibility DFSolar/GLsolar. The UV data by BR#058, BR#059 and BR#052 were corrected precisely by “JMA external lamp correction method” (Ito et al.: 2000).

**Difference of DS Ozone Measurements between Brewer MKIII and Dobson Spectrophotometers in JMA Network from 2002(2001) to 2007**

*M. Ito and K. Miyagawa*

*Japan Meteorological Agency*

**Abstract:** In atmospheric ozone monitoring careful data quality control plays an essential role for correct analysis and evaluation of the long-term ozone trend. In this connection the first WMO summary report on the comparison of total ozone measurements of Dobson and Brewer spectrophotometers (WMO : 2003) states that the simultaneous operation of Dobson and Brewer instruments at the same station is highly recommended to improve the reliability of the total ozone measurements of the station, and indicates some seasonal change in the trend of total ozone difference between Brewer and Dobson. Recently, Vanicek (2006) presented the analysis results of the relation between high-quality simultaneous Dobson, Brewer ground and satellite total ozone observations, and suggested the difference between Brewer and Dobson to be attributed to the influence of temperature on ozone absorption coefficients and total sulphur dioxide. The JMA Brewer MKIII UV network is run concurrently with a long-term Dobson ozone network comprised of Sapporo, Tsukuba, Kagoshima, Naha, and Syowa Antarctica including Minamitorishima with Brewer MKII, which has been the replacement of old Brewer MKII UV network from January 1990 to December 2001(Fig.1 to Fig.3 and Table 1). These overlapped networks continue to store quasi-simultaneous total ozone comparison data as well as SO2. This paper presents the ds O3 observation results and the ds O3 difference between Brewer and Dobson without any data correction as long-term and high-quality multiple Dobson-Brewer comparison in the same network. The summary of the observation results from 2002 (2001) to 2007 are given below.

**Brewer #066: A New Location in Italy**

*H. Diémoz1, C. Tarricone1, G. Agnesod1 A. Siani2, G. R. Casale2*

1. ARPA Valle d’Aosta
2. La Sapienza, Rome University

**Abstract:** On January 25, 2007, Brewer spectrophotometer MKIV #066 was moved from Ispra-JRC (45.8 °N, 8.6 °E, 240 m) – operational since 1991 - to Saint-Christophe, Aosta (45.7 °N, 7.4 °E, 569 m, Fig. 1). The instrument is installed on the roof of the building of ARPA Valle d’Aosta (Environmental Protection Agency) which is now the agency in charge. The new location is in a semi-rural context, just out-of-town, slightly influenced by anthropogenic activity. The site is in a large valley floor with a wide field of view.
The absolute calibration was performed by the IOS inc. (International Ozone Service) in April 19-23, 2007, showing that the instrument is still working reliably. Measurements of total ozone, total nitrogen dioxide, AOD and spectral UV irradiance are regularly carried out following the schedule used at Ispra. Brewer data can be seen in real time on the ARPA Valle d'Aosta website (www.uv-index.vda.it). Because of the topography of the territory, thermal inversions and Föhn events (low ambient humidity, higher temperature and strong wind) are very frequent which makes very interesting the study of aerosol optical depths and total ozone content.

Comparison of Ozoneonde, TOMS and Brewer Spectrophotometer Measurements in Ankara

M. Ekici
Turkish State Meteorological Service

Abstract: The amount of ozone at any location depends on variations on all of time scales. The ozone distributions vary with latitude, with different seasonal cycles at different locations. In the mid-latitudes, ozone in the upper stratosphere has regular seasonal variations. Ankara (39° 55' N: 32° 55' E) which is the capital of Turkey is located at the center of Anatolia.

In this study, our aim is comparing ground-based measurement with satellite measurement in order to understand the availability of the satellite measurement for the other parts of the country that we have not any record. Our study has shown that TOMS satellite data has a great correlation with the Brewer measurement. However, there is no close relation between the ozonesonde data and the Brewer measurement. This is mainly caused by the difference of measurement techniques. Ozonesonde can measure only through 35 km, although the Brewer is 50 km.

As a result, it is very difficult to reach any conclusion with this short period of Brewer data. It is required long-term measurement to get the exact solution.

Ozone, UV and Aerosol Observations with Brewer Instruments at Uccle

Hugo De Backer and Anne Cheymol
Royal Meteorological Institute of Belgium

Abstract: The Royal Meteorological Institute of Belgium at Uccle (50°48N, 4°21E) has a long tradition in observations with Brewer Instruments. Since 1983 a MKII instrument is in used, which was equipped with a UV-B port in 1989. In 2001 a MKIII instrument was installed at the same location. The behaviour of both instruments is monitored. This work shows that long term data on ozone column, UV-B radiation and Aerosol Optical Depth observations can be obtained in a reliable manner with these instruments.

Validation of the Aerosol Optical Depth Obtained with the Langley Plot Method from Brewer

A. Cheymol\textsuperscript{1}, H. De Backer\textsuperscript{2}, W. Joseffson\textsuperscript{2} and R. Stübi\textsuperscript{3}
\textsuperscript{1}Royal Meteorological Institute of Belgium
\textsuperscript{2}Swedish Meteorological and Hydrological Institute
\textsuperscript{3}MeteoSwiss

Abstract: The AOD at 320nm retrieved from the Direct Sun observations of the Brewer [Cheymol and De Backer, 2003] using the Langley Plot Method (LPM) are compared to AOD measured by a CSEM2000N sunphotometer at Norrköping in Sweden [Cheymol et al., 2006] for 368 nm. The AOD from co-located Brewers are compared at Arosa in Switzerland and at Uccle.
Brewer and Dobson Ozone Data Inter-comparison at El Arenosillo
J.M. Vilaplana¹ and A. Redondas²
¹INTA
²Spanish Meteorological Service. Izaña Observatory

Abstract: There have been 2200 quasi-simultaneous Brewer and Dobson observations (in between 10 minutes) have been analysed. Brewer and Dobson measurements are in general well correlated. It is found a seasonal oscillation in the differences Brewer-Dobson. These differences are close to 0% in summer time and up to 3% in winter time, like in Arosa. The Brewer instrument generally overestimates the ozone versus the Dobson in 1% in average for air mass between 1-1.5. A strong air mass dependence is seen in the Brewer-Dobson differences with different behaviour to that shown by other authors. The ozone slant path dependence is mainly due to SZA dependence. These are preliminary results and it is planned a deeper study including the effect of the effective temperature of the stratosphere in the Brewer-Dobson differences.

Comparison of OMI-Derived Total Column Ozone with Four Ground Sites in the U.K. and Ireland
Andrew R.D. Smedley, John S. Rimmer and Ann R. Webb
University of Manchester

Abstract: The Aura spacecraft was launched 15 July 2004 and its Ozone Monitoring Instrument (OMI) has been producing data since 17 August that year (Levelt et al 2006). During this period four ground sites in the UK and Ireland have been measuring total column ozone. Three of these operate Brewer spectrophotometers, #075 at Reading and #088 at Valentia being single monochromator instruments, whilst #172 at Manchester is a double monochromator. Lerwick observations are recorded by a Dobson ozone spectrophotometer, #32 currently being in operation.

Each of the ground sites calculates a daily average of the total ozone column, with the data for Reading and Manchester distinguishing between direct sun (DS) and zenith sky (ZS) measurements. In the first case these values are compared with the OMI daily average, ordinarily consisting of one or two overhead passes. Subsequently for Reading and Manchester the comparison is made between the OMI measurement and each individual ground measurement, providing this occurs within 30 minutes of the overpass.

Variation of Ozone, UV and AOD by Brewer Spectrophotometer over Matrouh, Egypt
W. Sharobiem
Egyptian Meteorological Administration

Abstract: Since November 1998, Brewer spectrophotometer mark II No.143 has measured the ozone column at Matrouh (31°20´N, 27°13´E, 36m). Matrouh is a flat sandy area at the coast of the Mediterranean Sea (northwest coast of Egypt) and it is a summer resort. The measurements taken from the direct sun observations at five isolated wavelengths in the UV-B: 306.3nm, 310.1nm, 313.5nm, 316.7nm and 320.1nm. We have used the monthly mean observations of aerosol optical depth (AOD) in the UV at 320.1nm, Ozone column in DU and UVB radiation in mW/m²/nm over a long time period from January 1999 to December 2006 to calculate the trend and seasonal variation. A monthly variation of ozone, UVB and AOD take maximum values at spring, summer and hot season (late spring and early summer) respectively. Mean seasonal variations of the ozone, DUV and AOD are 316DU, 102.76mW/m²/nm and 0.12 in spring, summer and summer respectively. Trend analysis on the mean annual ozone, DUV and AOD gives positive trend from 1999-2006. The annual trend amounts of ozone, DUV and AOD are 0.059, 0.120 and 0.001 respectively.
New NOAA-EPA UV Network: Characterization, Software and Hardware Issues of MKIV Brewers
Patrick Disterhoft, Peter Kiedron and Scott Stierle
Cooperative Institute for Research in Environmental Sciences, University of Colorado

Abstract: Various aspects and issues related to the Brewer instrument characterization and software/hardware have been examined. These issues include maximizing the schedule duty cycle, PMT temperature and throughput, UV scan processing, dark count hysteresis and elevated dark counts in the N2 mode. These elevated dark signals and magnitudes that vary between different modes and routines have been discovered and examined. It was determined that the Brewer did not shutter the exit slits before exiting certain routines while in schedule (DS, ZS, UX, & PS). This leaves the PMT exposed to direct sun or global irradiances.

NOAA–EPA Brewer Network Website Diagnostic and Monitoring Tools
Scott Stierle, Patrick Disterhoft and Peter Kiedron
Cooperative Institute for Research in Environmental Sciences, University of Colorado

Abstract: The NOAA-EPA Brewer network has a new Website which includes diagnostic and monitoring tools. These tools include support for schedule characteristics for stations located both at high and low latitudes. Daily integrated summaries of the extended UV scans, individual UV spectral scans, direct sun ozone and NO2 measurements, and Umkehr profiles. Diagnostics of dark counts, standard and mercury lamps scans the long-term monitoring of Daily statistics are presented.

Ozone profile during Antarctic Ozone Hole 2005 at Punta Arenas (Lat.53S; long. 70.9W), Chile Umkehr (Brewer) and Ozone Soundings
Claudio Casiccia1,2 Neusa Paes Leme3, Félix Zamorano1,2 Roberta Viana2
1 UMAG; Universidad de Magallanes
2 CEQUA; Centro de Estudios del Cuaternario de Fuego-Patagonia y Antártica
3 INPE; Instituto Nacional de Pesquisas Espaciais, Brazil

Abstract: Punta Arenas, Chile (53.2S;70.9W) is the southern most Chilean city, with about 120000 inhabitants. Total column ozone (from the Brewer #180) and vertical profile data from the year 2005 for Punta Arenas are presented. During the ozone sonde campaigns, when 25 sondes were launched, vertical ozone profile (AM and PM) with the Umkehr technique were also performed using Brewer #180. The results shown here are still preliminary. The Umkehr profiles under the influence of the Antarctic Ozone Hole we must study them with more detail, also the `a priori` profiles. It is probable that important discrepancies may be the result of the cloudy conditions during the observations period. The campaign was developed by National Institute for Space Research (INPE-Brazil), CEQUA Foundation and University of Magallanes (Chile).

A Variability of the Total Ozone by the Brewer Ozone Spectrophotometer over Pohang in Korea
Gi-Man Hong and Chun-Ho Cho
Yonsei University, Korea

Abstract: The characteristics of the total ozone variations measured by the ground-based Brewer Ozone Spectrophotometer and the Total Ozone Mapping Spectrometer (TOMS) over Pohang are statistically examined from January 1994 to December 2004. First of all, in the correlation analysis of the total ozone measured from the Brewer Ozone Spectrophotometer and the TOMS, the correlation coefficient was 0.88 and the used data were 2190. The annual mean value of the total ozone is 311 DU with the standard deviation of 13 DU. The maximum and the minimum value were found in March (343 DU) and in September (282 DU), respectively. It was also revealed that
the longest seasonal variation is in Spring (341 DU) and the smallest is in Autumn (283 DU). The time series data of the total ozone indicates that the annual variation is significant and the variations for three months and six months are relatively weak. Finally, the annual mean total ozone in Pohang (Brewer), Seoul (Brewer) and Busan (TOMS) are 311 DU, 321 DU and 304 DU, respectively.

13. CLOSING OF THE MEETING

McElroy officially closed the meeting and thanked the local hosts: J. Rimmer, A. Webb, A. Smedley and P. Kelly for their hospitality and assistance during the meeting.

****
# ANNEX A

10th Biennial Brewer Workshop Hosted by the University of Manchester,  
(Northwich, United Kingdom, 4-8 June 2007)  

## List of Participants

<table>
<thead>
<tr>
<th>Last Name</th>
<th>First Name</th>
<th>Affiliation</th>
<th>Country</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boot</td>
<td>Kristian</td>
<td>Kipp &amp; Zonen</td>
<td>Netherlands</td>
<td><a href="mailto:kristian.boot@kippzonen.com">kristian.boot@kippzonen.com</a></td>
</tr>
<tr>
<td>Casiccia</td>
<td>Claudio</td>
<td>University of Magallanes</td>
<td>Chile</td>
<td><a href="mailto:claudio.casiccia@umag.cl">claudio.casiccia@umag.cl</a></td>
</tr>
<tr>
<td>Cheymol</td>
<td>Anne</td>
<td>Royal Meteorological Institute</td>
<td>Belgium</td>
<td><a href="mailto:anne.cheymol@oma.be">anne.cheymol@oma.be</a></td>
</tr>
<tr>
<td>Cucchiarelli</td>
<td>Paolo</td>
<td>Italian Air Force - Met Service</td>
<td>Italy</td>
<td><a href="mailto:cucchiarelli@meteoam.it">cucchiarelli@meteoam.it</a></td>
</tr>
<tr>
<td>De Backer</td>
<td>Hugo</td>
<td>Royal Meteorological Institute</td>
<td>Belgium</td>
<td><a href="mailto:hugo.debacker@kmi-irm.be">hugo.debacker@kmi-irm.be</a></td>
</tr>
<tr>
<td>Diemoz</td>
<td>Henri</td>
<td>ARPA Valle d’Aosta</td>
<td>Italy</td>
<td><a href="mailto:h.diemoz@arpa.vda.it">h.diemoz@arpa.vda.it</a></td>
</tr>
<tr>
<td>Dieterink</td>
<td>Ben</td>
<td>Kipp &amp; Zonen BV</td>
<td>Netherlands</td>
<td><a href="mailto:bdieterink@kippzonen.com">bdieterink@kippzonen.com</a></td>
</tr>
<tr>
<td>Disterhoft</td>
<td>Patrick</td>
<td>NOAA/CIRES</td>
<td>USA</td>
<td><a href="mailto:patrick.disterhoft@noaa.gov">patrick.disterhoft@noaa.gov</a></td>
</tr>
<tr>
<td>Ekici</td>
<td>Mithat</td>
<td>State Meteorological Service</td>
<td>Turkey</td>
<td><a href="mailto:mekici@meteogr.gov">mekici@meteogr.gov</a></td>
</tr>
<tr>
<td>Fioletov</td>
<td>Vitali</td>
<td>Environment Canada</td>
<td>Canada</td>
<td><a href="mailto:vitali.fioletov@ec.gc.ca">vitali.fioletov@ec.gc.ca</a></td>
</tr>
<tr>
<td>Fragkos</td>
<td>Kostas</td>
<td>Aristotle Univ. of Thessaloniki</td>
<td>Greece</td>
<td><a href="mailto:kostasc@auth.gr">kostasc@auth.gr</a></td>
</tr>
<tr>
<td>Hare</td>
<td>Ed</td>
<td>Environment Canada</td>
<td>Canada</td>
<td><a href="mailto:ed.hare@ec.gc.ca">ed.hare@ec.gc.ca</a></td>
</tr>
<tr>
<td>Hong</td>
<td>Gi Man</td>
<td>KGAWMETRI/KMA</td>
<td>Rep. of Korea</td>
<td><a href="mailto:hongkm@kma.go.kr">hongkm@kma.go.kr</a></td>
</tr>
<tr>
<td>Kawai</td>
<td>Kazuhiro</td>
<td>Prede Co., Ltd.</td>
<td>Japan</td>
<td><a href="mailto:prede@gb3.so-net.ne.jp">prede@gb3.so-net.ne.jp</a></td>
</tr>
<tr>
<td>Kawashima</td>
<td>Kenichi</td>
<td>Finetec Co., Ltd.</td>
<td>Japan</td>
<td><a href="mailto:kenichi_kawahima@finetec.co.jp">kenichi_kawahima@finetec.co.jp</a></td>
</tr>
<tr>
<td>Kiedron</td>
<td>Peter</td>
<td>CIERES/NOAA</td>
<td>USA</td>
<td><a href="mailto:peter.kiedron@noaa.gov">peter.kiedron@noaa.gov</a></td>
</tr>
<tr>
<td>Kim</td>
<td>Jhoon</td>
<td>Yonsei University</td>
<td>Rep. of Korea</td>
<td><a href="mailto:jkim2@yonsei.ac.kr">jkim2@yonsei.ac.kr</a></td>
</tr>
<tr>
<td>Koskela</td>
<td>Tapani</td>
<td>Finnish Meteorological Institute</td>
<td>Finland</td>
<td><a href="mailto:tapani.koskela@fmi.fi">tapani.koskela@fmi.fi</a></td>
</tr>
<tr>
<td>Kouremeti</td>
<td>Natalia</td>
<td>Aristotle Univ. of Thessaloniki</td>
<td>Greece</td>
<td><a href="mailto:nakou@skiathos.physics.auth.gr">nakou@skiathos.physics.auth.gr</a></td>
</tr>
<tr>
<td>Labow</td>
<td>Gordon</td>
<td>NASA - GSFC</td>
<td>USA</td>
<td><a href="mailto:labow@blasp.gsfc.nasa.gov">labow@blasp.gsfc.nasa.gov</a></td>
</tr>
<tr>
<td>Lam</td>
<td>Ka Se</td>
<td>Hong Kong Polytechnic Univ.</td>
<td>Hong Kong</td>
<td><a href="mailto:cekslam@polyu.edu.hk">cekslam@polyu.edu.hk</a></td>
</tr>
<tr>
<td>Lopez</td>
<td>Maria</td>
<td>Inst. Nacional de Meteorologia</td>
<td>España</td>
<td><a href="mailto:mlopez@inm.es">mlopez@inm.es</a></td>
</tr>
<tr>
<td>Mahito</td>
<td>Ito</td>
<td>AOT/JMA</td>
<td>Japan</td>
<td><a href="mailto:mahito-itou@met.kishou.go.jp">mahito-itou@met.kishou.go.jp</a></td>
</tr>
<tr>
<td>McElroy</td>
<td>Tom</td>
<td>Environment Canada</td>
<td>Canada</td>
<td><a href="mailto:Tom.McElroy@sympatico.ca">Tom.McElroy@sympatico.ca</a></td>
</tr>
<tr>
<td>Montero</td>
<td>Jose</td>
<td>Inst. Nacional de Meteorologia</td>
<td>España</td>
<td><a href="mailto:redfqa@inm.es">redfqa@inm.es</a></td>
</tr>
<tr>
<td>Peshin</td>
<td>Sunil</td>
<td>India Met. Department</td>
<td>India</td>
<td><a href="mailto:peshinsk@yahoo.co.in">peshinsk@yahoo.co.in</a></td>
</tr>
<tr>
<td>Petropavlovskikh</td>
<td>Irina</td>
<td>NOAA/ESRL/GMD</td>
<td>USA</td>
<td><a href="mailto:irina.petro@noaa.gov">irina.petro@noaa.gov</a></td>
</tr>
<tr>
<td>Redgrave</td>
<td>Peter</td>
<td>Kipp &amp; Zonen</td>
<td>UK</td>
<td><a href="mailto:peter.redgrave@kippzonen.com">peter.redgrave@kippzonen.com</a></td>
</tr>
<tr>
<td>Redondas</td>
<td>Alberto</td>
<td>Inst. Nacional de Meteorología</td>
<td>Spain</td>
<td><a href="mailto:arendondas@inm.es">arendondas@inm.es</a></td>
</tr>
<tr>
<td>Rimmer</td>
<td>John</td>
<td>University of Manchester</td>
<td>UK</td>
<td><a href="mailto:john.s.rimmer@manchester.ac.uk">john.s.rimmer@manchester.ac.uk</a></td>
</tr>
<tr>
<td>Sasamoto</td>
<td>Kazutoshi</td>
<td>Prede Co., Ltd.</td>
<td>Japan</td>
<td><a href="mailto:prede@gb3.so-net.ne.jp">prede@gb3.so-net.ne.jp</a></td>
</tr>
<tr>
<td>Savastiouk</td>
<td>Vladimir</td>
<td>Environment Canada</td>
<td>Canada</td>
<td><a href="mailto:Vladimir.Savastiouk@ec.gc.ca">Vladimir.Savastiouk@ec.gc.ca</a></td>
</tr>
<tr>
<td>Schill</td>
<td>Herbert</td>
<td>MeteoSwiss Arosa, Switzerland</td>
<td>Switzerland</td>
<td><a href="mailto:herbert.schill@meteoswiss.ch">herbert.schill@meteoswiss.ch</a></td>
</tr>
<tr>
<td>Sharobiem</td>
<td>Wafik</td>
<td>Egyptian Met. Authority</td>
<td>Egypt</td>
<td><a href="mailto:wafiek@yahoo.com">wafiek@yahoo.com</a></td>
</tr>
<tr>
<td>Siani</td>
<td>Anna Maria</td>
<td>Sapienza University of Rome</td>
<td>Italy</td>
<td><a href="mailto:annamaria.siani@uniroma1.it">annamaria.siani@uniroma1.it</a></td>
</tr>
<tr>
<td>Smedley</td>
<td>Andy</td>
<td>University of Manchester</td>
<td>UK</td>
<td><a href="mailto:andrew.smedley@manchester.ac.uk">andrew.smedley@manchester.ac.uk</a></td>
</tr>
<tr>
<td>Staehelin</td>
<td>Johannes</td>
<td>Inst. Atmos. Climate Sci., ETHZ</td>
<td>Switzerland</td>
<td><a href="mailto:Johannes.Staehelin@env.ethz.ch">Johannes.Staehelin@env.ethz.ch</a></td>
</tr>
<tr>
<td>Toth</td>
<td>Zoltan</td>
<td>Hungarian Met. Service</td>
<td>Hungary</td>
<td><a href="mailto:toth.z@met.hu">toth.z@met.hu</a></td>
</tr>
<tr>
<td>Vilaplana</td>
<td>Jose Manuel</td>
<td>INTA / El Arenosillo</td>
<td>Spain</td>
<td><a href="mailto:vilplanagim@inta.es">vilplanagim@inta.es</a></td>
</tr>
<tr>
<td>Vuerich</td>
<td>Emanuele</td>
<td>Italian Air Force – Ital. Met Serv.</td>
<td>Italy</td>
<td><a href="mailto:vuerich@meteom.it">vuerich@meteom.it</a></td>
</tr>
<tr>
<td>Wardle</td>
<td>David</td>
<td>Environment Canada</td>
<td>Canada</td>
<td><a href="mailto:david.wardle@ec.gc.ca">david.wardle@ec.gc.ca</a></td>
</tr>
<tr>
<td>Wilawan</td>
<td>Kumharn</td>
<td>University of Manchester</td>
<td>UK</td>
<td><a href="mailto:wilawan.kumharn@postgrad.manchester.ac.uk">wilawan.kumharn@postgrad.manchester.ac.uk</a></td>
</tr>
<tr>
<td>Willis</td>
<td>Paul</td>
<td>AEA</td>
<td>UK</td>
<td><a href="mailto:paul.willis@eaet.co.uk">paul.willis@eaet.co.uk</a></td>
</tr>
</tbody>
</table>
Group Photo of Participants at the 10th Biennial Brewer Workshop, Northwich, United Kingdom, 4 - 8 June 2007.
ANNEX B

10th Biennial Brewer Workshop hosted by the University of Manchester,
(Northwich, United Kingdom, 4-8 June 2007)

Final Agenda

**NOTICE to presenters: Tentatively, each talk will be allotted 15 minutes plus some time for questions**

**Sunday, June 3, 2007**
Travel day. An “ice-breaker” is planned for the evening. Attendees are invited to meet in the lobby of Floatel at 18:30 to have an informal night out to meet one another and renew old acquaintances. A “no host” get together is arranged at the Anderton Pub. Refer to the accommodations web site for directions.

**Monday, June 4, 2007**

09:00-09:10 Welcome Opening of meeting, J. Rimmer
09:10-09:15 Introduction by Meeting Chairman, C.T. McElroy
09:15-10:00 Physical Principles I: The Dobson, Measuring Ozone, A Historical Perspective, C.T. McElroy

Session I (10:00-12:00h including coffee break).

Themes: Station Observations and Data Comparisons

10:00-10:20 Comparison between Brewer and Dobson total ozone measurements at Arosa, Switzerland, J. Staehelin
10:20-10:40 O3,SO2,NO2 and UV-B measurements with Brewer Spectrophotometer at Maitri, Antarctica, S. Peshin

10:40-11:10 Coffee break

11:10-11:30 The homogenized Brewer triad total ozone records of Arosa, Switzerland, H. Schill
11:30-11:50 Comparison of Brewer and Dobson Measurements in Seoul, Korea, J. Kim et. al.

Lunch 12:00-14:00

Poster Session (14:00-15:30, includes coffee break)

A Variability of the Total Ozone by Brewer Ozone Spectrophotometer over Pohang in Korea, G-M. Hong
Recalculate 11 years of Total Ozone - Brewer #115, K-S Lam
Diffuse, reflected and global spectral UV observations using Brewer spectrophotometers at Tsukuba, Japan, M. Ito
Difference of DS ozone measurements between Brewer MKIII and Dobson spectrophotometers in JMA network from 2002(2001) to 2007, M. Ito
Brewer #066: A New Location In Italy, H. Diemoz
Ozone profile during Antarctic Ozone Hole 2005 at Punta arenas (Lat.53S; long. 70.9W), Chile
Umkehr (Brewer) and ozone soundings, C. Casiccia
Comparison of Ozonesonde, TOMS and Brewer Spectrophotometer Measurements in Ankara, M. Ekici
Ozone, UV and Aerosol Observations with Brewer Instruments at Uccle, H. De Backer
Validation of the aerosol optical depth obtained with the Langley Plot method from Brewer, A. Cheymol
Brewer and Dobon ozone data intercomparison at El Arenosillo, J.M. Vilaplana Guerrero
Comparison of OMI-derived total column ozone with four ground sites in the U.K. and Ireland, A. Smedley
New NOAA-EPA UV Network: Characterization, Software and Hardware Issues of MKIV Brewers, P. Disterhoft
NOAA–EPA Brewer Network Website Diagnostic and Monitoring Tools, P. Disterhoft
Variation of Ozone, UV and AOD by Brewer Spectrophotometer over Matrouh, Egypt, W. Sharobiem

**Session II**
15:30-16:15 Physical Principles II: Optical Characteristics of the Brewer (Tutorial), D. Wardle
16:15-17:00 Physical Principles III: Brewer Measurements and Stray Light (Tutorial), C.T. McElroy

**Tuesday, June 5, 2007**

**Session III** (09:00-12:00h including coffee break)

Themes: Data Retrievals and New Techniques
09:00-09:20 The short-term and long-term tropospheric ozone variability available from zenith sky measurements, I. Petropvalovskikh
09:20-09:40 Remaining Issues Concerning Satellite/Ground-based Column Ozone Retrievals, G. Labow
09:40-10:00 Data Quality Considerations of Global Ground-Based Network, V. Fioletov
10:30-11:00 Coffee break
11:00-11:40 Technical Panel and SAG Ozone Report, CT McElroy
11:40-12:00 Ozone Absolute Calibration Langley, A Redondas

**Lunch 12:00-14:00**

**Session IV** (14:00-15:30)
14:00-14:20 Brewer Algorithm sensitivity, A. Redondas
14:20-14:40 Validation of the aerosol optical depth obtained with the Langley Plot method from Brewer, A. Cheymol
14:40-15:00 Kipp & Zonen Updates, B. Dieterink
15:00-15:30 Coffee break

**Poster Session** (15:30-17:00)
Continuation of Poster Session and Brewer Subcommittee meeting

**Wednesday, June 6, 2007**
Tour of the University of Manchester laboratories and Brewer facilities.

NOTE: In parallel with the University of Manchester tour is a national DEFRA meeting where ozone research in the UK is being presented.
A "no host" dinner in the city to follow.
Thursday, June 7, 2007

Session V (09:00-10:00h including coffee break)
Keynote Speaker

09:00-10:00  Special Keynote Presentation - Jonathan Shanklin, BAS
10:15-10:45  Coffee break

Session VI (10:30-12:00h including coffee break)

Themes: UV Studies, Calibrations and Data Analysis
10:45-11:05  Applying SL Corrections to ETC for DS Observations, V. Savatiouk
11:05-11:25  SAUNA II Preliminary Results, T. Koskela
11:25-11:45  Total ozone and UV radiation measurement program in the Italian Air Force Met Service background air pollution monitoring network, E. Vuerich

Lunch 12:00-14:00

Session VII (14:00-15:00)

Themes: Software and Analysis Techniques
14:00-14:10  Brief RBCC-E campaign update, A. Rendondas
14:10-14:30  Brewer data analysis techniques, V. Savatiouk
14:30-14:50  Brewer Data Analysis Software, V. Fioletov
14:50-15:10  Software Developments, J. Rimmer
15:10-15:30  WOUDC and BDMS, E. Hare

Coffee break 15:30-16:00

Session VIII (16:00-17:00)
16:00-17:00  Discussion, Conclusions and Recommendations, C.T. McElroy

Friday, June 8, 2007

Session IX (09:00-12:00)
Topics: Instrument Operations and Data Analysis

09:00-12:00  Practical Demonstrations with the Brewer instrument including “Hands on” session
14:00-16:00  Demonstration of the Brewer diagnostics database, V. Savatiouk
14:00-16:00  Demonstration of the Brewer Data Analysis Software, V. Fioletov
14:00-16:00  Demonstration of the Brewer Umkehr Software, I. Petropavlovskikh

Saturday June 9, 2007
09:00-12:00  Continuation of the Practical Demonstrations as required.
ANNEX C

List of Acronyms and Abbreviations

AOD   Aerosol Optical Depth
BDMS  Brewer Data Management System
CFC   Chloro-flouro Carbons
CIMEL CIMEL Electronique (France)
CIMO  Commission for Instruments and Methods of Observation (WMO)
CIRES Cooperative Institute for Research in Environmental Sciences (NOAA)
DS    Direct Sun
DU    Dobson Units
EPA   Environmental Protection Agency (USA)
ETHZ  Eidgenössische Technische Hochschule Zürich (Switzerland)
ETC   Extraterrestrial Coefficients
ExtCSV Extended Comma Separated Values
FM    Focused Moon
FOV   Field of View
FTP   File Transmission (Transport) Protocol
GAW   Global Atmospheric Watch
GMT   Greenwich Mean Time
GOME  Global Ozone Monitoring Experiment
GSFC  Goddard Space Flight Center (NASA)
GTS   WMO Global Transmission System
GUI   Graphical User Interface
INM   Instituto Nacional de Meteorologia (Spain)
ISO   International Systems Organization
LAN   Local Apparent Noon
MLO   Mauna Loa Observatory, Hawaii
NASA  National Aeronautical Space Administration
NOAA  National Oceanic and Atmospheric Administration
NRT   Near-real time
PMT   Photomultiplier Tube
RBCC-E Regional Brewer Calibration Centre for Europe (WMO)
RDCC  Regional Dobson Calibration Centre
SAUNA Sodankylä Total Column Ozone Inter-comparison
SL    Standard Lamp
SOP   Standard Operating Procedures
SPF   Sun Protection Factor
SZA   Solar Zenith Angle
TOMS  Total Ozone Mapping Spectrometer
UMK04 Umkehr processing algorithm 2004
WIP   Work in Progress
WMO   World Meteorological Organization
WOU DC World Ozone and Ultraviolet radiation Data Centre
ZS    Zenith Sky
<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Date/Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Summary Report on the Status of the WMO Background Air Pollution Monitoring Network as at April 1981.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Review of the Chemical Composition of Precipitation as Measured by the WMO BAPMoN by Prof. Dr. Hans-Walter Georgii, February 1982.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Effects of Sulphur Compounds and Other Pollutants on Visibility by Dr. R.F. Pueschel, April 1983.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1981, May 1983.</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>General Consideration and Examples of Data Evaluation and Quality Assurance Procedures Applicable to BAPMoN Precipitation Chemistry Observations by Dr. Charles Hakkari, July 1983.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Forecasting of Air Pollution with Emphasis on Research in the USSR by M.E. Berlyand, August 1983.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Extended Abstracts of Papers to be Presented at the WMO Technical Conference on Observation and Measurement of Atmospheric Contaminants (TECOMAC), Vienna, 17-21 October 1983.</td>
<td></td>
</tr>
</tbody>
</table>


26. Sulphur and Nitrogen in Precipitation: An Attempt to Use BAPMoN and Other Data to Show Regional and Global Distribution by Dr. C.C. Wallén. April 1986 (WMO TD No. 103).


29. Recommendations on Sunphotometer Measurements in BAPMoN Based on the Experience of a Dust Transport Study in Africa by Dr. Guillaume A. d’Almeida. September 1985 (WMO TD No. 67).


43. Recent progress in sunphotometry (determination of the aerosol optical depth). November 1986.


58. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at BAPMoN sites for the years 1986 and 1987 (WMO TD No. 306).


62. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at BAPMoN sites for the year 1988 (WMO TD No. 355).


69. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at Global Atmosphere Watch (GAW)-BAPMoN sites for the year 1989 (WMO TD No. 400).


72. Integrated Background Monitoring of Environmental Pollution in Mid-Latitude Eurasia by Yu.A. Izrael and F.Ya. Rovinsky, USSR (WMO TD No. 434).


75. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at Global Atmosphere Watch (GAW)-BAPMoN sites for the year 1990 (WMO TD No. 447).


77. Report of the WMO Meeting of Experts on Carbon Dioxide Concentration and Isotopic Measurement Techniques, Lake Arrowhead, California, 14-19 October 1990.


84. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at GAW-BAPMoN sites for the year 1991 (WMO TD No. 543).
85. Chemical Analysis of Precipitation for GAW: Laboratory Analytical Methods and Sample Collection Standards by Dr Jaroslav Santroch (WMO TD No. 550).
89. 4th International Conference on CO₂ (Carqueiranne, France, 13-17 September 1993) (WMO TD No. 561).
91. Extended Abstracts of Papers Presented at the WMO Region VI Conference on the Measurement and Modelling of Atmospheric Composition Changes Including Pollution Transport, Sofia, 4 to 8 October 1993 (WMO TD No. 563).
97. Quality Assurance Project Plan (QAPjP) for Continuous Ground Based Ozone Measurements (WMO TD No. 634).


113. The Strategic Plan of the Global Atmosphere Watch (GAW) (WMO TD No. 802).


120. WMO-UMAP Workshop on Broad-Band UV Radiometers (Garmisch-Partenkirchen, Germany, 22 to 23 April 1996) (WMO TD No. 894).


124. Fifth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, (Geneva, Switzerland, 7-10 April 1997) (WMO TD No. 898)

125. Instruments to Measure Solar Ultraviolet Radiation, Part 1: Spectral Instruments (lead author G. Seckmeyer) (WMO TD No. 1066)

126. Guidelines for Site Quality Control of UV Monitoring (lead author A.R. Webb) (WMO TD No. 884).


129. Guidelines for Atmospheric Trace Gas Data Management (Ken Masarie and Pieter Tans), 1998 (WMO TD No. 907).


131. WMO Workshop on Regional Transboundary Smoke and Haze in Southeast Asia (Singapore, 2 to 5 June 1998) (Gregory R. Carmichael). Two volumes.


133. Workshop on Advanced Statistical Methods and their Application to Air Quality Data Sets (Helsinki, 14-18 September 1998) (WMO TD No. 956).


135. Sixth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (Zurich, Switzerland, 8-11 March 1999) (WMO TD No.1002).


139. The Fifth Biennial WMO Consultation on Brewer Ozone and UV Spectrophotometer Operation, Calibration and Data Reporting (Halkidiki, Greece, September 1998)(WMO TD No. 1019).


146. Quality Assurance in monitoring solar ultraviolet radiation: the state of the art. (WMO TD No. 1180).


149. Comparison of Total Ozone Measurements of Dobson and Brewer Spectrophotometers and Recommended Transfer Functions (prepared by J. Staehelin, J. Kerr, R. Evans and K. Vanicek) (WMO TD No. 1147).

150. Updated Guidelines for Atmospheric Trace Gas Data Management (Prepared by Ken Maserie and Pieter Tans (WMO TD No. 1149).


154. WMO/IMEP-15 Trace Elements in Water Laboratory Intercomparison. (WMO TD No. 1195).


159. IGOS-IGACO Report - September 2004 (WMO TD No. 1235)


170. WMO/GAW Expert Workshop on the Quality and Applications of European GAW Measurements (Tutzing, Germany, 2-5 November 2004) (WMO TD No. 1367).


172. WMO Global Atmosphere Watch (GAW) Strategic Plan: 2008 – 2015 (WMO TD No. 1384)


174. World Data Centre for Greenhouse Gases Data Submission and Dissemination Guide (WMO TD No. 1416).