5.1. McMurdo Station (01/29/05 – 1/19/06)

The 2005/06 season at McMurdo Station is defined as the period between the site visits 1/25/05 – 1/29/05 and 1/19/06 – 1/24/06. The season opening and closing calibrations were performed on 1/28/05 and 1/20/06, respectively. Volume 15 solar data comprises the period 01/29/05 – 1/19/06. A total of 17054 scans are part of the published McMurdo Volume 15 dataset. Only 0.5% of all possible scans are missing because of technical problems. The Eppley PSP and TUVR radiometers installed at McMurdo were replaced by identical instruments during the site visit in 2006.

The SUV-100 spectroradiometer performed well during the reporting period, but there were some problems with auxiliary instruments:

- **Intermittency in Eppley TUVR data**
  Data from the Eppley TUVR radiometer were intermitted on several days during the last half of the season. See Section 5.1.4 for a listing of missing days. We generally cannot confirm the calibrations provided by Eppley Laboratory Inc. and therefore advise data users to treat TUVR data as “uncalibrated,” and use them for referential purposes only.

- **Time errors**
  The GPS receiver that is used to update the computer time erroneously reset the time by one day on 3/6/05. Data measured on 3/5/05 were partly overwritten and lost. Published data have the correct time stamp but are incomplete.

5.1.1. Irradiance Calibration

The site irradiance standards for the McMurdo 2005/06 season were the lamps 200W005, 200W019, and M-543. Lamp M-764 was used as traveling standard during the site visit in 2005; lamp 200W017 was the traveling standard in 2006. Both traveling lamps have been calibrated by Optronic Laboratories in March 2001.

The calibrations of lamps M-764 and 200W017 were compared in San Diego against our long-term standards M-763 and 200W022 shortly before the McMurdo site visit. The latter two lamp have been calibrated by Optronic Laboratories in March 2001 and have rarely been used since. The calibration of the traveling standard 200W017 agreed with M-763 and 200W022 to within ±1%. This confirms that the original calibration of lamp 200W017 from March 2001 was still valid as of January 2006. The calibration of M-764 was systematically different from the calibrations of the other three lamps by 2-3%. Further analysis revealed that this lamp has drifted by approximately 2% during the last two years.

The McMurdo site standards 200W005 and M-543 were lastly recalibrated in 2002 by comparison with lamp M-764 using scans performed during the site visits in 2001 and 2002 (see Section 4.2.1.5 for details of the procedure). Analysis of the absolute scans performed at McMurdo during 2005 revealed that the calibration of lamp 200W005 has changed by approximately 2% between September and December 2005. The lamp was recalibrated by transferring the calibration of 200W017 to the lamp using scans performed during the 2006 site visit. Both “closing” scans of the Volume 15 season and “opening” scans of the Volume 16 were used. For calibration of solar data from the 2005/06 period, the 2002 calibration of lamp 200W005 was used until September 2005. From December 2005 onward, the new calibration was used.

The site standard 200W019 has an Optronic Laboratories certificate from September 1998, and was not recalibrated.

Figure 5.1.1 shows the Volume 15 season opening calibrations performed on 1/28/05. All standards agreed at the ±0.5% level. The good agreement of the site standards with the traveling M-764 is puzzling as comparisons of lamp M-764 with the South Pole site standards performed on 1/21/05 exhibited a 1.5 – 2.5% bias in the calibration of M-764 (Section 5.3.1). This bias is consistent with results of the comparison of M-764 with the long-term standards M-763 and 200W022 described above. As of February 2006, the discrepancy is still unresolved.

Figure 5.1.2 shows the Volume 15 season closing calibrations performed on 1/20/06 relative to the traveling standard 200W017. The calibration of the site standards agreed with the calibration of lamp 200W017 to within ±1%.

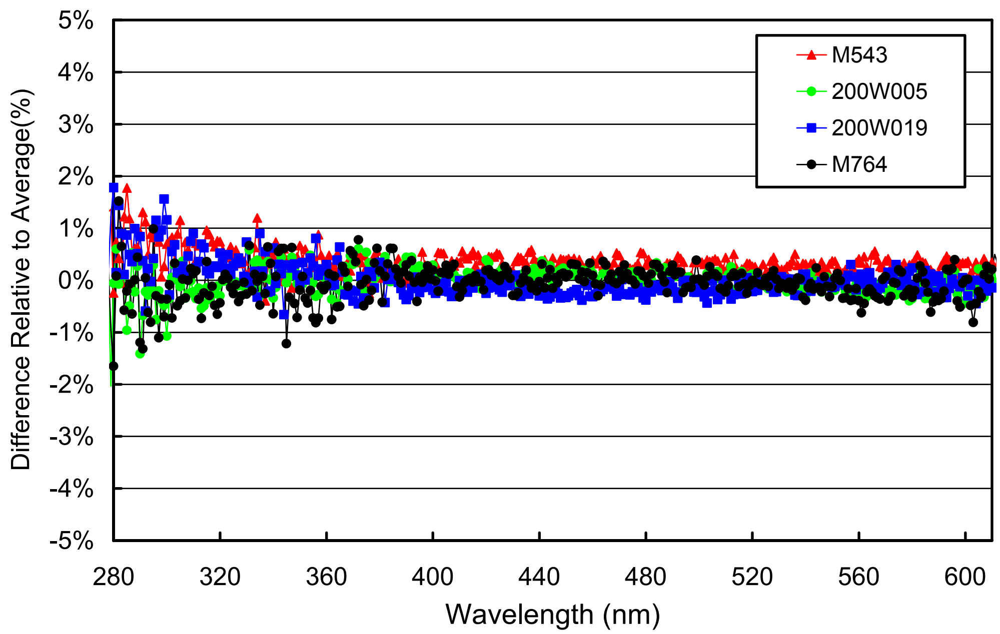

Figure 5.1.1. *Comparison of McMurdo lamps M-543, 200W005, and 200W019 and the BSI traveling standard M-764 at the beginning of the season (1/28/05). The 2002 calibration of lamp 200W005 was used.*

5.1.2. Instrument Stability

The stability of the spectroradiometer over time is primarily monitored with bi-weekly calibrations utilizing the site irradiance standards and daily response scans of the internal irradiance reference lamp. The stability of this lamp is monitored with the TSI sensor, which is independent from possible monochromator and PMT drifts. By logging the PMT currents at several wavelengths during response scans, changes in monochromator throughput and PMT sensitivity can be detected.

Figure 5.1.3 shows the changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily response scans. TSI measurements indicate that the internal reference lamp became brighter by approximately 2% over the course of the season. The PMT currents at 300 and 400 nm varied by ±2%, with lowest values in winter. This temporal pattern has been observed also in previous seasons; its reason is unknown. Changes in system response indicated in Figure 5.1.3 are automatically corrected during data processing.

A total of six different calibrations were applied to the solar measurements of Volume 15. An overview of the calibration periods is given in Table 5.1.2. Figure 5.1.4 shows ratios of the calibration functions applied during Periods 2-4, relative to the function of Period 1. The calibrations applied for Period 2 (7/1/05 - 11/6/05) is consistent to within 1% with the calibration applied before Polar Night. After mid-November, the system responsivity started to drift and the last calibration (Period 4) differed from the original calibration by 5-6%. By applying four different calibrations during the period 11/7/05 – 1/22/06, drift-related uncertainties in solar data were reduced to 2%.

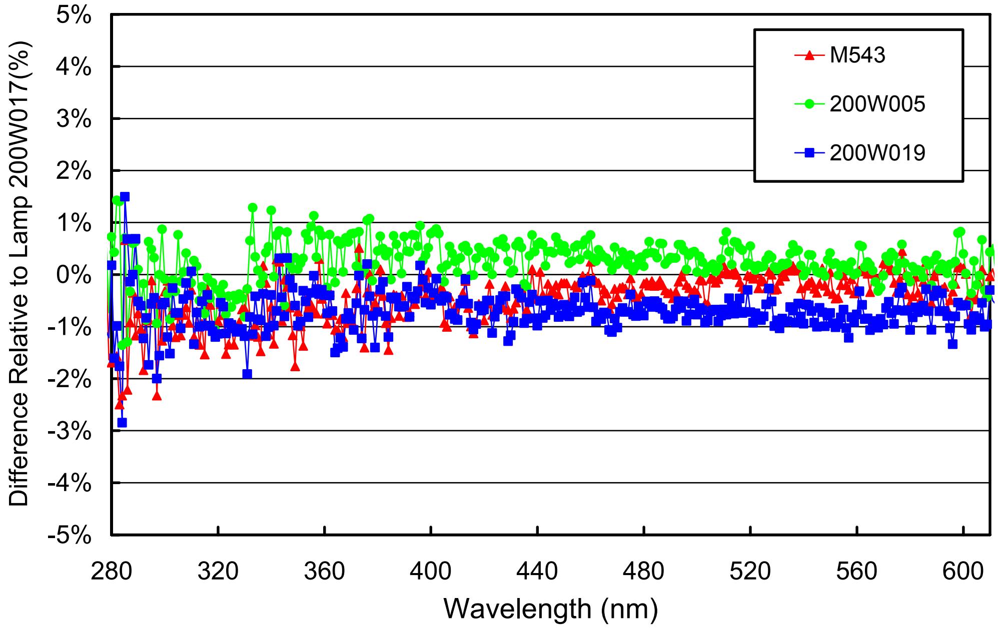

Figure 5.1.2. *Comparison of McMurdo lamps M-543, 200W005, and 200W019 with the BSI traveling standard 200W017 at the end of the season (1/20/06). The new calibration of lamp 200W005 was used.*

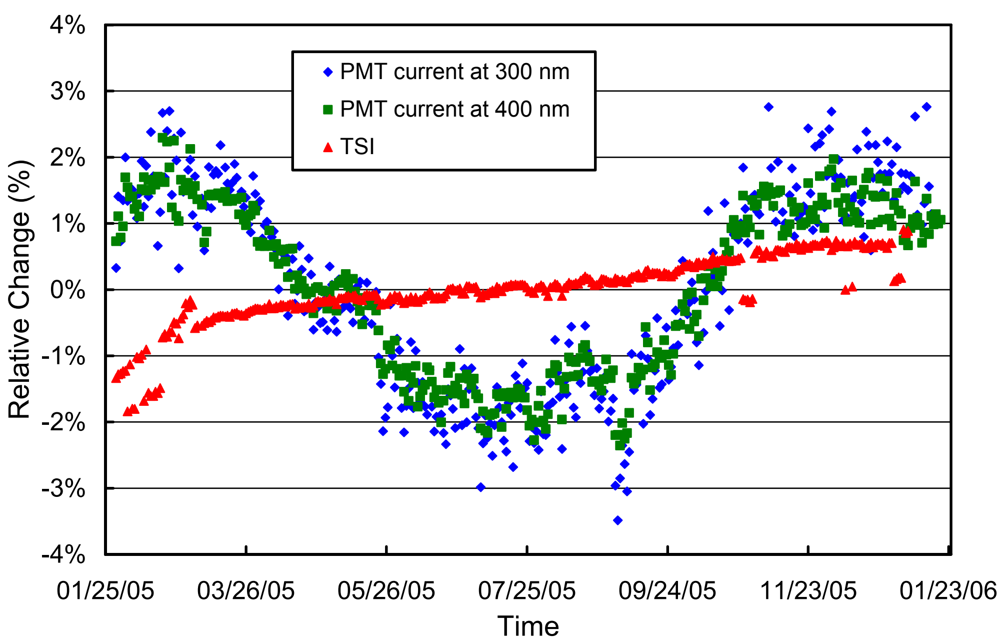

Figure 5.1.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal derived from measurements of the internal irradiance reference lamp during the McMurdo 2005/06 season. The data is normalized to the average value of the whole season.*

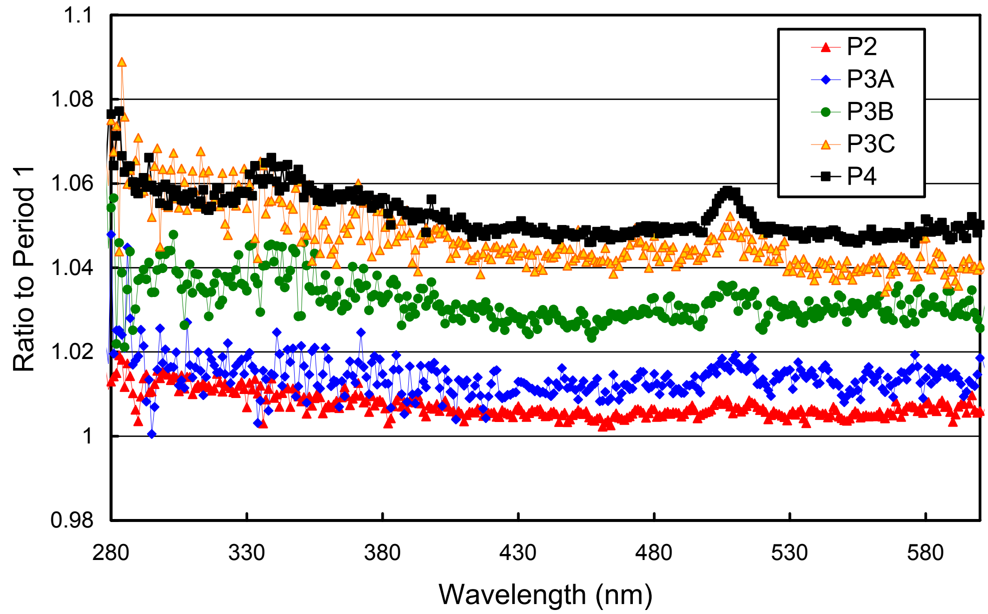

Figure 5.1.4 *Ratio of irradiance assigned to the internal reference lamp relative to Period P1 (01/27/05 - 6/30/05).*

Figure 5.1.5 presents the relative standard deviation calculated from the individual absolute scans of each period. These data are useful for estimating the variability of the calibrations in each period. The variability is typically less than 1% for wavelengths above 300 nm in all periods, indicating very good consistency of individual absolute scans.

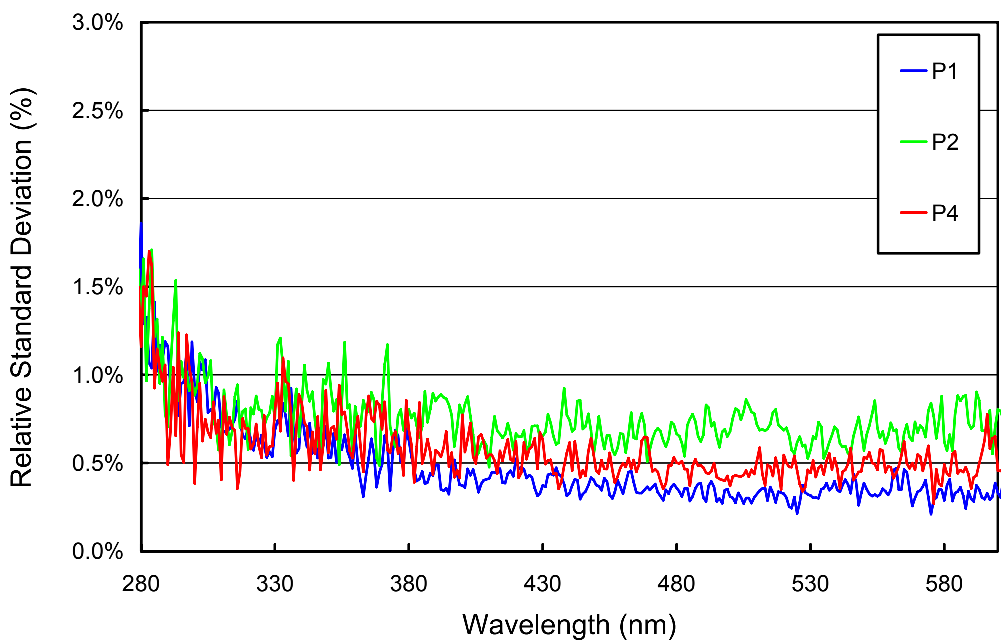

Figure 5.1.5. *Ratio of standard deviation and average calculated from absolute calibration scans performed in Periods P1, P2, and P3.*

Table 5.1.1: Calibration periods of McMurdo Volume 15 data.

Period name	Period range	Number of Absolute scans	Remarks
P1	01/27/05 - 06/30/05	17	Before Polar Night
P2	07/01/05 - 11/06/05	7	After Polar Night
P3A	11/07/05 - 11/23/05	1	
P3B	11/24/05 - 12/09/05	1	
P3C	12/10/05 - 12/23/05	1	
P4	12/24/05 - 01/22/06	10	

5.1.3. Wavelength Calibration

Wavelength stability of the system was monitored with the internal mercury lamp. Information from the daily wavelength scans was used to homogenize the data set by correcting day-to-day fluctuations in the wavelength offset. After this step, there may still be a deviation from the correct wavelength scale, but this bias should ideally be the same for all days. Figure 5.1.6 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 403 pairs of scans were evaluated. For 92% of the days, the offset change was smaller than ±0.025 nm; for 98% of the days it was smaller than ±0.055 nm. The wavelength difference between two consecutive scans was larger than 0.1 nm and data from these days were adjusted accordingly.

After data was corrected for day-to-day wavelength fluctuations, the wavelength-dependent bias between this homogenized data set and the correct wavelength scale was determined with the Version 2 Fraunhofer-line correlation method (*Bernhard et al*., 2004). This analysis suggested that the monochromator's wavelength mapping has slightly changed over the year and that better wavelength accuracy can be achieved by splitting the data volume into three period with a different correction function applied in each period. The resulting correction functions are shown in Figure 5.1.7. Periods named W1, W2 and W3 refer to periods 1/29/05 – 3/4/05, 3/5/05 – 12/11/05, and 12/12/05 – 1/21/06, respectively.

After data had been wavelength corrected using the shift-functions described above, the wavelength accuracy was tested again with the Version 2 Fraunhofer-line correlation method. The results are shown in Figure 5.1.8 for four UV wavelengths. For UV wavelengths smaller than 320 nm or larger than 390 nm, residual shifts are typically smaller than ±0.1 nm. There are three periods in February and March when shifts at 350 nm exceed ±0.1 nm. These periods are: 2/7/05 – 2/10/05, 2/20/05 – 2/22/05, and 3/2/05 – 3/4/05. More detailed analysis revealed that wavelengths between 330 and 380 nm are affected (The comparatively large variability at these wavelengths is also indicated by the relatively large error-bars for period W1 in Figure 5.1.7). A similar problem was also observed in data from the 2004/2005 period (Volume 14; see the associated Operations Report). The reason of the increased variability is unknown but likely caused by the mechanics of the monochromator. Inspection of the monochromator during the site visit in 2006 did not reveal the source of the problem. The increased variability is difficult to correct and affects published data. Wavelength shifts in the UVA of this magnitude are fortunately of little consequence for most applications. Only if spectra are compared on a wavelength-by-wavelength basis, a discernible scatter may be observed. The actual wavelength uncertainty of the instrument may be slightly larger as indicated in Figure 5.1.8 due to wavelength fluctuations during a given day (Figure 5.1.8 shows only one point per day), and possible systematic errors of the Fraunhofer-correlation method (*Bernhard et al*., 2004).

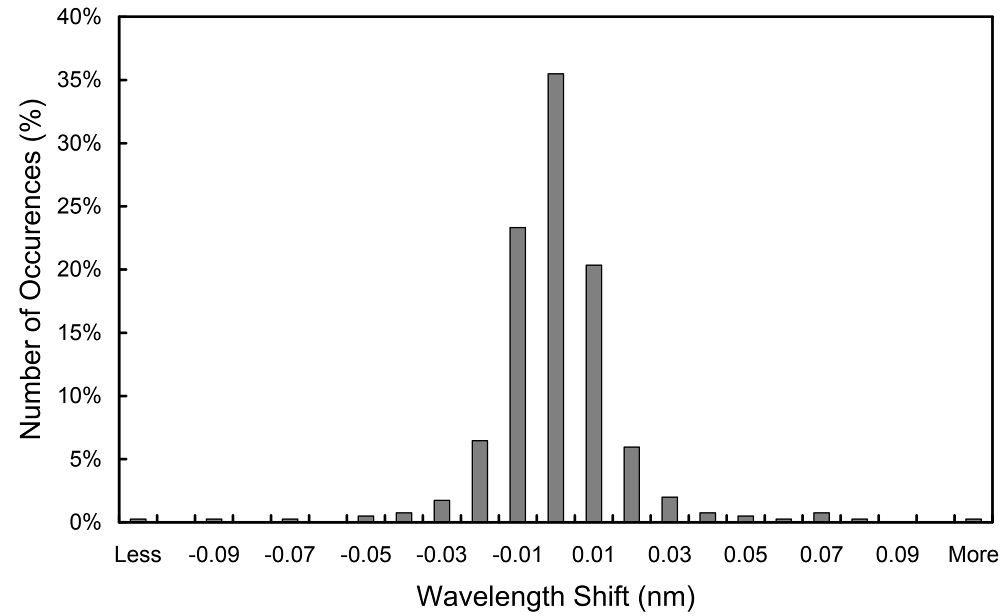

Figure 5.1.6. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

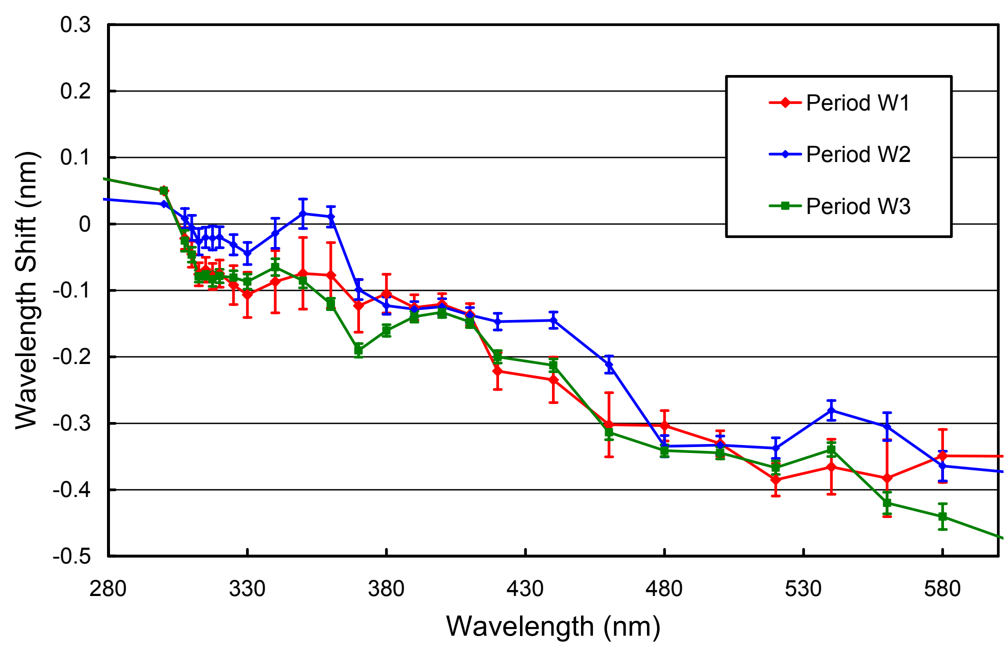

Figure 5.1.7. *Monochromator non-linearity correction functions for McMurdo 2005/06 data. The error bars indicate the 1σ-variation in each period.*

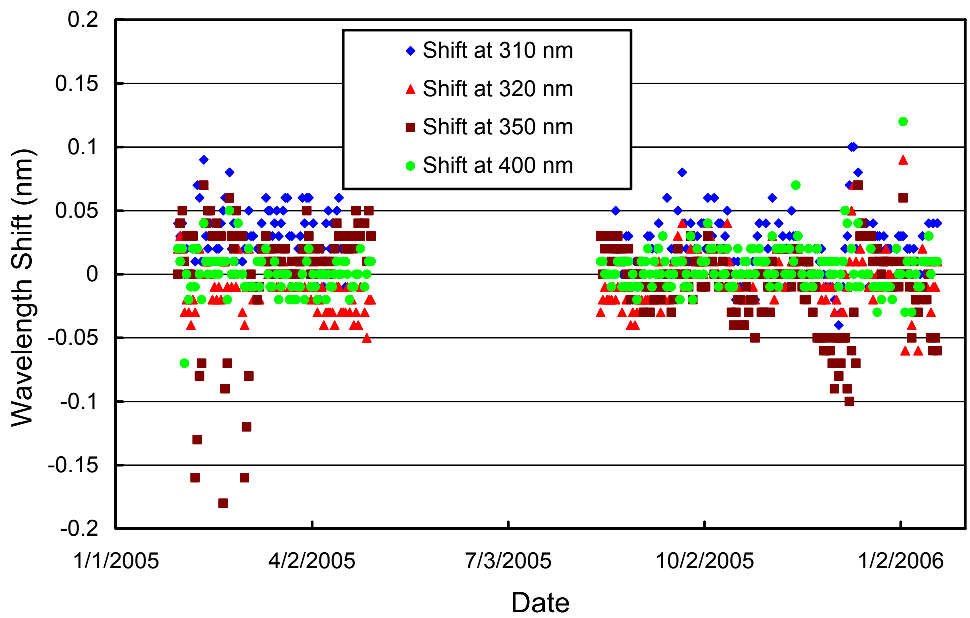

Figure 5.1.8. *Check of the wavelength accuracy of final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season. No correlation data is available during Polar Night.*

Data from the external mercury scans do not have a direct influence on data products. They are, however, an important part of instrument characterization. Figure 5.1.9 illustrates the difference between internal and external mercury scans collected during the 2005 and 2006 site visits. The wavelength scale of the figure is the same as applied during solar measurements. The peak of the external scans agrees well with the nominal wavelength of 296.73 nm, whereas the peak of the internal scans is shifted about 0.06 nm to shorter wavelengths. External scans have a bandwidth of about 1.00 nm FWHM. The bandwidth of the internal scan is 0.72 nm. External scans have the same light path as solar measurements and therefore represent the monochromator's bandpass relevant for solar scans. The scans at start and end of the season are very consistent.

5.1.4. Missing Data

A total of 17054 scans are part of the published McMurdo Volume 15 dataset. These are 95% of the maximum possible number of data scans. Of all missing data scans, 99, 299, and 301 were superseded by absolute, wavelength, and response scans, respectively. Approximately 0.5% of all scans were missed due to technical problems: all scans of 3/6/05 were lost when the GPS unit erroneously reset the computer time by one day. 12 scans are missing on 12/30/05 due to a scheduled power outage.

Data from the Eppley TUVR radiometer were intermitted on many days during the last half of the season. Due to this problem, TUVR data from the following periods were excluded from the final data set:
10/22/05 - 10/25/05, 11/13/05 - 11/15/05, 11/24/05 - 11/26/05, 11/29/05 - 12/02/05, 12/04/05, 12/12/05 - 01/12/06, 01/17/06.

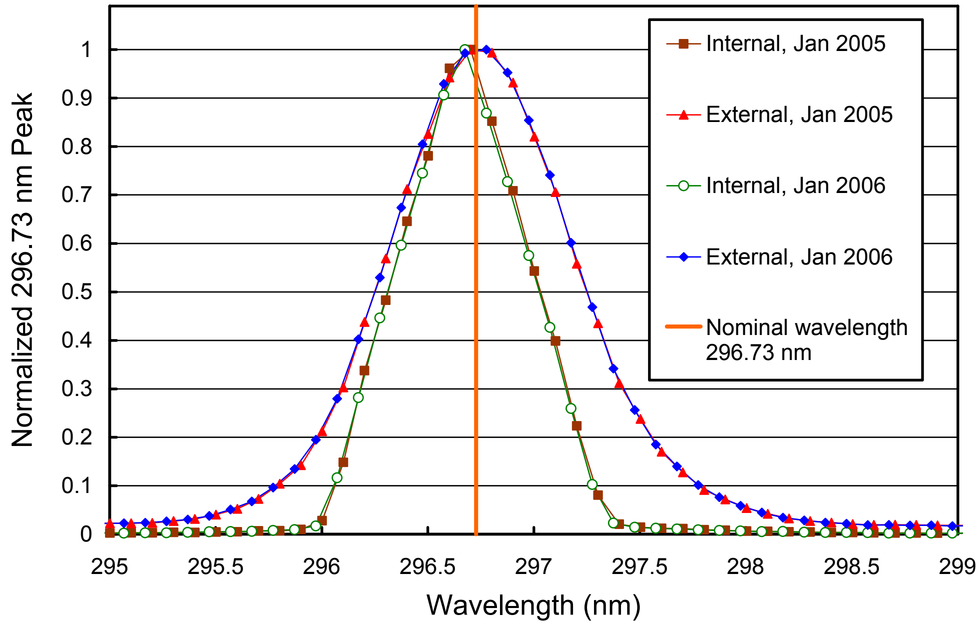

Figure 5.1.9 *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements. It is assumed that the wavelength registration of the monochromator did not shift between internal and external scans, which were close in time.*

5.1.5. GUV Data

The GUV-511 radiometer, which is installed next to the SUV-100, was calibrated against final SUV-100 measurements following the procedure outlined in Section 4.3.1. All channels of the GUV-511 instrument were stable to within ±2%. Due to the good stability only one set of calibration factors was applied for the entire period of Volume 15.

Data products were calculated from the calibrated measurements according to the procedure outlined in Section 4.3.2. Figure 5.1.10. shows a comparison of GUV-511 and SUV-100 erythemal irradiance based on final Volume 15 data. For solar zenith angles smaller than 80°, measurements of the two instruments agree to within ±2.5% (±1σ). Data from the GUV-511 radiometer tend to be lower for large SZAs or large total ozone columns. During these conditions, measurements of the instrument's 305-nm channel are close to the detection limit. We advise data users to use SUV-100 rather than GUV-511 data whenever possible, in particular for low-Sun conditions.

Figure 5.1.11 shows a comparison of total ozone measurements from the GUV-511 radiometer and the Ozone Monitoring Instrument (OMI) installed on NASA's AURA satellite. GUV-511 ozone values were calculated as described in Section 4.3.3 and are plotted for SZAs smaller than 80°. On average, GUV-511 ozone values are larger by 2.3% than OMI data. However, the bias is larger for small ozone columns. This bias is partly caused by the influence of the ozone profile on calculations of the total ozone column, which has not been considered in the calculation of GUV-511 total ozone data. For most accurate total ozone information, we advice data users to use total ozone values calculated from SUV-100 measurements that are part of the "Version 2" dataset, available at www.biospherical.com/nsf/Version2/Version2.asp.

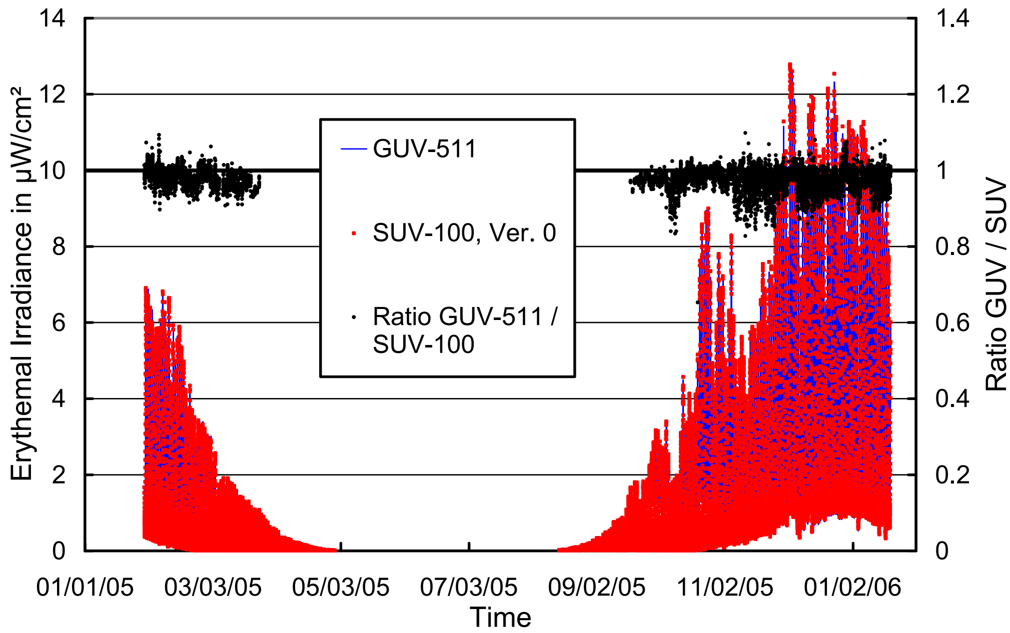

Figure 5.1.10. *Comparison of erythemal irradiance measured by the SUV-100 spectroradiometer and the GUV-511 radiometer. All data are based on "Version 0" (cosine-error uncorrected) data.*

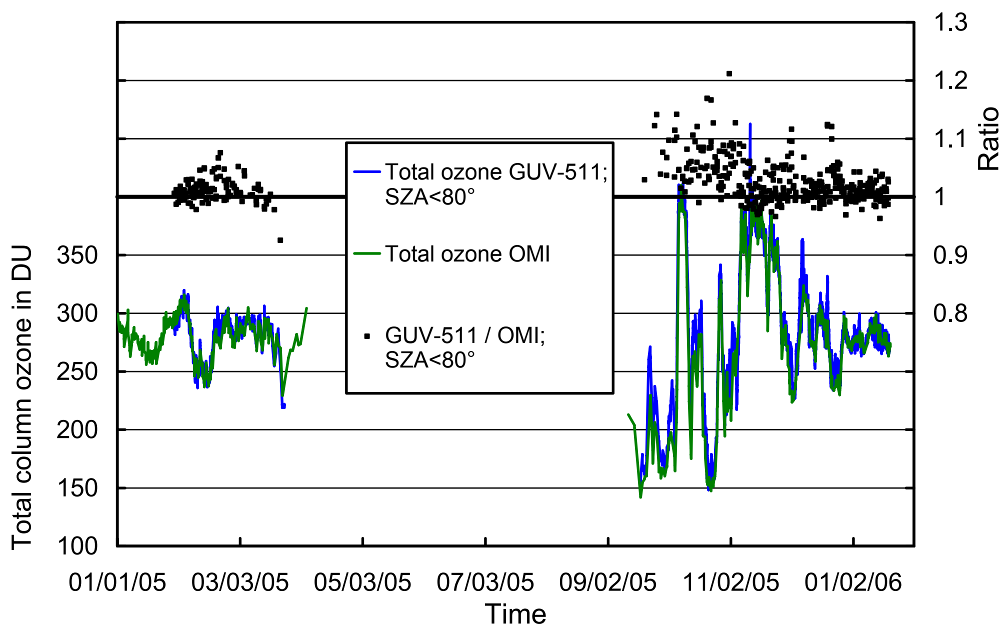

Figure 5.1.11. *Comparison of total column ozone measurements from GUV-511 and OMI. GUV-511 measurements are plotted in 15 minute intervals. For calculating the ratio of both data sets, only GUV-511 measurements concurrent with OMI overpass data were evaluated.*