5.1. McMurdo Station (01/15/07 – 1/25/08)

The 2007/08 season at McMurdo Station is defined as the period between the site visits 1/12/07 – 1/24/07 and 1/25/08 – 2/1/08. Season opening and closing calibrations were performed on 1/16/07 and 1/25/08, respectively. Volume 17 solar data comprise the period 01/15/07 – 1/25/08. A total of 18808 scans are part of the McMurdo Volume 17 dataset. Only 31 scans were missed due to technical problems. Variations in the monochromator's wavelength setting were larger than typical between November 2007 and January 2008. The wavelength uncertainty of data of this period is 0.08 nm (±2σ).

5.1.1. Irradiance Calibration

The site irradiance standards for the McMurdo 2007/08 season were the lamps 200W005, 200W019, and M-543. Lamp 200W017 was used as traveling standard during the site visit in 2007; lamp M-763 was the traveling standard in 2008.

<u>On-site standards</u>
The standard 200W019 has an Optronic Laboratories certificate from September 1998. The standard 200W005 was originally calibrated by Optronic Laboratories in November 1996. It has been recalibrated by comparison with standard 200W017 using scans performed during the 2006 site visit at McMurdo (see Volume 15 Operations Report). Lamp M-543 was originally calibrated in 1999 against lamp M-764 (the traveling standard at that time), and recalibrated in 2002, also against M-764. Analysis of scans performed with the three lamps and traveling standards during the last two years has indicated that the brightness of the three on-site standards had changed since their last calibration. Specifically, measurements with the SUV's internal TSI sensor indicated that lamp 200W019 became abruptly dimmer by about 2.5% in November 2007 after having suffered a similar change in brightness in 2006. Lamp M-543 became gradually dimmer by 1.5% during the last year. The brightness of lamp 200W005 has not changed appreciably during the last two years, but data indicate a gradual change since its calibration in 1996. The three lamps were re-calibrated against the traveling standard M-763 using "closing" scans from the 2008 site visit.

<u>Traveling standards</u>
Lamp 200W017 has been calibrated by Optronic Laboratories in March 2001. Comparisons with BSI's long-term standard 200W022 on 6/1/06 indicated that the lamp had become brighter by 1.5±0.5% but has been stable since. Lamp M-763 was one of BSI's long-term standards and was calibrated last by Optronic Laboratories in March 2001. Comparisons with 200W022 indicate that the lamp became gradually brighter by about 1.0±0.5% during the last years.

<u>Recalibration of traveling standards</u>
To reduce the uncertainty caused by changes in the brightness of lamps 200W017 and M-763, both lamps were recalibrated in June 2007 at BSI with a set of four 1000-W FEL lamps, which had been calibrated by the U.S. Central UV Calibration Facility (CUCF) in Boulder, Colo. This calibration procedure was complicated by the fact that the irradiance scale of the four FEL lamps refers to the detector-based scale of the National Institute of Standards and Technology established in 2000 (NIST2000; *Yoon et al*., 2002), whereas all solar data of the NSF UVSIMN refer to the source-based NIST scale from 1990 (NIST1990, *Walker et al*., 1987). The NIST2000 scale is about 1.3% larger than the NIST1990 scale. Data of certificates issued by the CUCF were converted to the NIST1990 scale before the calibration was transferred to the two traveling standards 200W017 and M-763. The calibration of both lamps was successively compared with that of lamp 200W022. The calibration of the three lamps agreed to within ±0.5%, confirming that the irradiance scale of 200W022 (which currently preserves UVSIMN's irradiance scale over the long-term) is consistent with the "NIST2000-to-NIST1990-converted" CUCF irradiance scale.

Unfortunately, the bulb of lamp M-763 was slightly rotated in its holder sometime in October 2007. Comparisons with other lamps performed before and after the misalignment indicated that the rotation changed the irradiance of lamp M-763 by about 2% in the UV and 1-2% in the visible. The effect of the misalignment was adjusted by applying a correction function to the calibration values of the lamp.

Recalibration of on-site standards

Lamps 200W005, 200W019, and M-543 were calibrated against "rotation-corrected" data of lamp M-763 using "closing" scans from the 2008 site visit. Figure 5.1.1 shows a comparison of the four lamp lamps after recalibration, confirming that their irradiance scales are consistent to within ±0.5%. Figure 5.1.2 shows a similar plot against traveling standard 200W017 based on the Volume 17 opening calibrations, performed on 1/15/07. There is good agreement between lamps 200W005 and 200W017, but the calibration of lamps M-543 and 200W019 differs from that of 200W017 by 2% and 3.5%, respectively. This level of disagreement is by and large consistent with the change observed by the SUV's TSI sensor. Because of these drifts, solar data of the Volume 17 season were mostly based on absolute scans with lamp 200W005. Only scans of 200W019 executed after November 2007 were used.

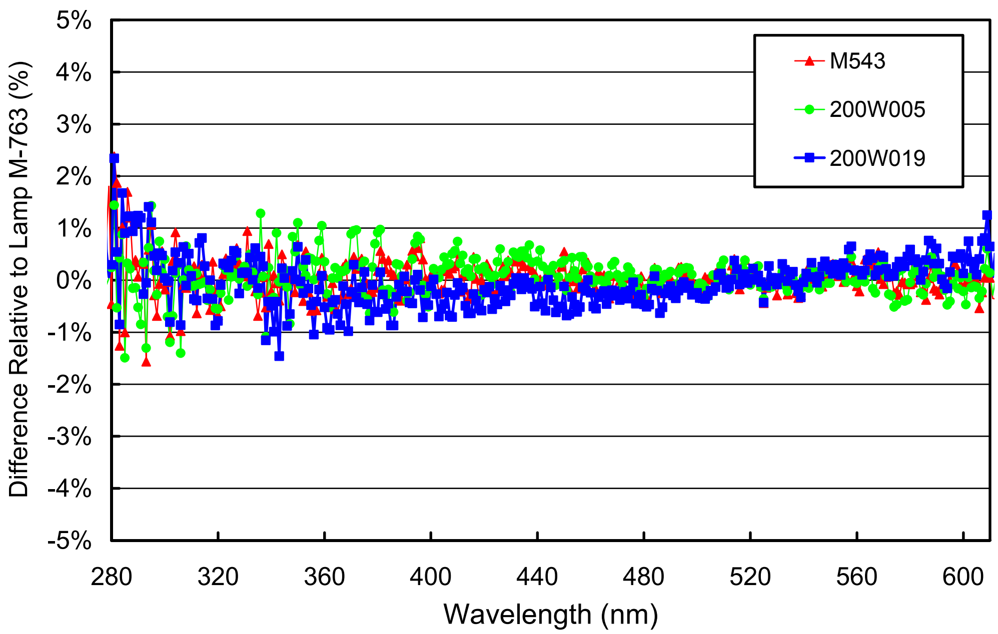

Figure 5.1.1. *Comparison of McMurdo lamps M-543, 200W005, and 200W019 with the BSI traveling standard M-763 on 1/25/08. Lamp M-763 had been calibrated in June 2007 against four 1000-Watt FEL standards provided by CUCF and corrected for the misalignment in its holder.*

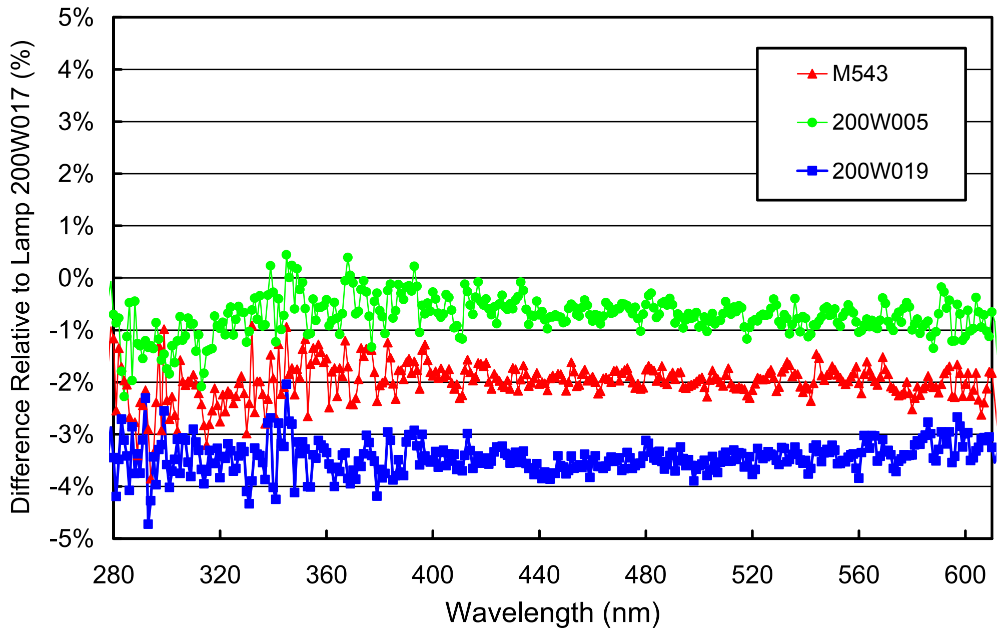

Figure 5.1.2. *Comparison of McMurdo lamps M-543, 200W005, and 200W019 with the BSI traveling standard 200W017 at the beginning of the Volume 17 season (1/15/07).*

5.1.2. Instrument Stability

The stability of the spectroradiometer over time is monitored with bi-weekly calibrations utilizing the site irradiance standards, daily response scans of the internal irradiance reference lamp, and by comparison with the collocated GUV-511 radiometer. The stability of the internal 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 changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily response scans. TSI measurements indicate that the internal lamp was stable to within ±2%. The PMT currents at 300 and 400 nm varied by ±3%, with lowest values in winter. This temporal pattern has been observed also in previous seasons and is probably related to seasonal changes in enclosure temperature. Changes in system response indicated in Figure 5.1.3 are automatically corrected during processing of solar data.

Nine calibration functions were applied to the solar measurements of Volume 17. Several functions are based on one absolute scan only. These functions were smoothed to reduce wavelength-to-wavelength noise in solar data. More details on calibration periods are provided in Table 5.1.1. Figure 5.1.4 shows ratios of the calibration functions applied during Periods P2 – P6, relative to the function of Period P1.

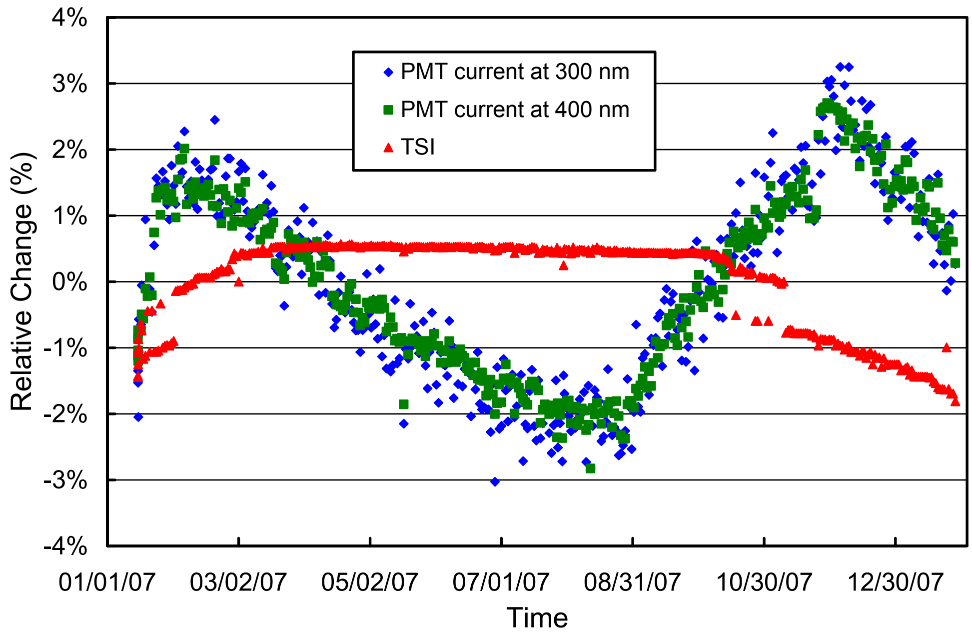

Figure 5.1.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal derived from measurements of the internal irradiance reference lamp during the McMurdo 2007/08 season. Data are normalized to the average value of the whole season.*

Table 5.1.1: Calibration periods for McMurdo Volume 17 data.

Period name	Period range	Number of Absolute Scans	Remarks
P1	01/15/07 – 02/21/07	5	
P1B	02/22/07 – 03/09/07	0	Interpolated from Periods P1 and P2
P2	03/10/07 – 06/21/07	3	Last period before Polar Night
P3	06/22/07 – 08/20/07	1	Smoothed
P3B	08/21/07 – 09/21/07	0	Interpolated from Periods P3 and P4, smoothed
P4	09/22/07 – 10/20/07	1	Smoothed
P5	10/21/07 – 11/05/07	1	Smoothed
P5B	11/06/07 – 11/14/07	0	Interpolated from Periods P5 and P6
P6	11/15/07 – 01/26/08	13	P6

Figure 5.1.5 presents the relative standard deviation calculated from the individual absolute scans for periods with more than one absolute scan. These data are useful for estimating the variability of calibrations. The variability is typically less than 1.0% for wavelengths above 300 nm, indicating good consistency of individual absolute scans. Data of period P2 are noisy because the standard deviation was calculated from three absolute scans only.

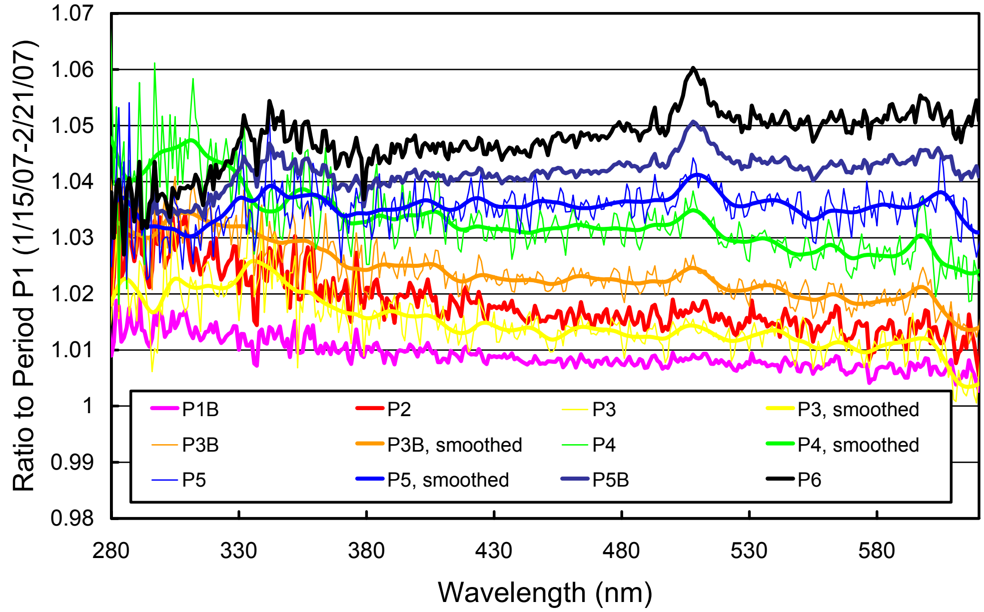

Figure 5.1.4 *Ratios of irradiance assigned to the internal reference lamp during periods P1B – P6, relative to Period P1.*

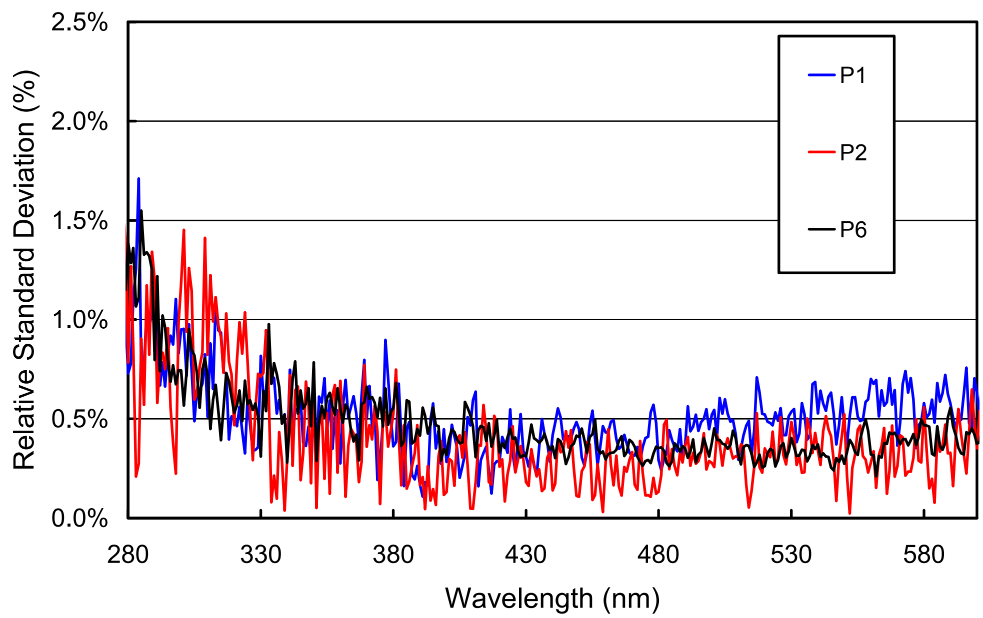

Figure 5.1.5. *Ratio of standard deviation and average calculated from absolute calibration scans performed in Periods P1, P2, and P6.*

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. Figure 5.1.6 shows differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 399 pairs of scans were evaluated. For 87% of the pairs, the offset change was smaller than ±0.025 nm; for 97% of the pairs it was smaller than ±0.055 nm. The wavelength difference between two consecutive scans was larger than 0.1 nm on five occasions, partly due to operator intervention. Data from these days were adjusted accordingly.

The wavelength stability was considerably better during the first part of the season (1/15/07 - 10/31/07; blue columns in Figure 5.1.6.) than during the second part (11/01/07 - 1/25/08; green column). Solar data from 11/01/07 onward have an additional wavelength uncertainty of about ±0.03nm. Inspection of the monochromator during the site visits in 2007 and 2008 suggested that a worn bearing was the cause of the problem. The bearing was lubricated.

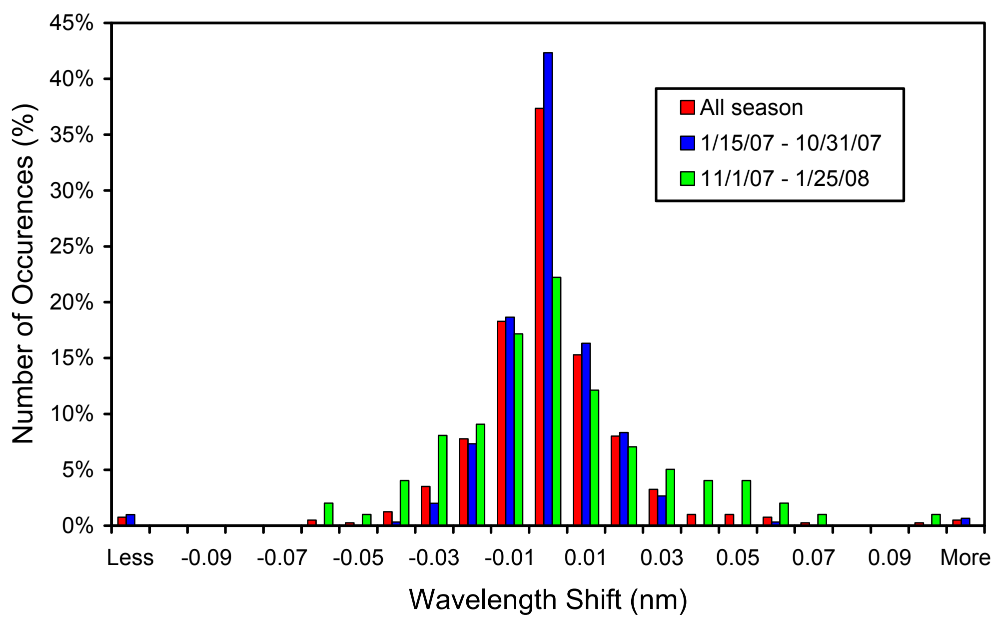

Figure 5.1.6. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means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

After data were 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 confirmed the deterioration of the monochromator's wavelength stability after 10/31/07. In addition to increased variability, the monochromator's wavelength mapping started to oscillate with a periodicity of about one month. A large number of correction functions would have been necessary to correct for this periodicity. Handling of many functions is difficult to implement in the Version 0 processing routines, but can easily be addressed as part of processing of Version 2 data. We therefore decided to use two correction functions for Version 0 data only, and address corrections of the remaining fluctuations as part of processing of Version 2 data. Final Version 0 data from 11/01/07 onward have a wavelength uncertainty of about ±0.08 nm (±2σ).

Figure 5.1.7 shows the two correction functions used for processing Version 0 data of the Volume 17 period. Figure 5.1.8 indicates the wavelength accuracy of final Version 0 data. Wavelength shifts were determined with the Version 2 Fraunhofer-line correlation method and are shown for five wavelengths in the UV and visible. Shifts from the first part of the year are typically smaller than ±0.05 nm. Shifts from the second part exhibit a periodicity of about one month, and typically vary between –0.08 nm and +0.08 nm.

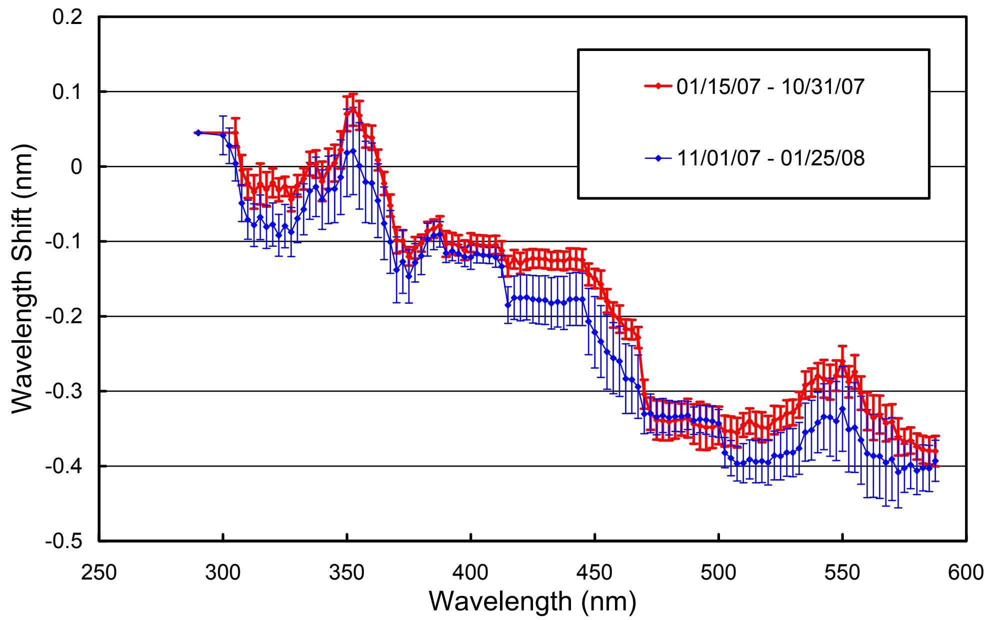

Figure 5.1.7. *Monochromator non-linearity correction functions for McMurdo 2007/08 data. Error bars indicate the 1σ-variation in each period.*

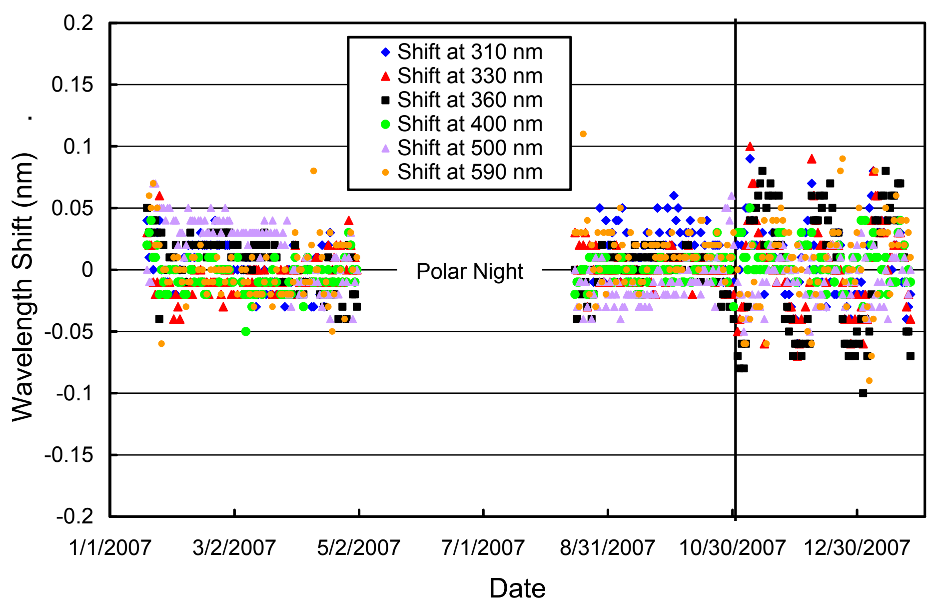

Figure 5.1.8. *Check of the wavelength accuracy of final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season. No correlation*

data is available during Polar Night. The vertical line indicates the time when the non-linearity correction functions was changed.

Scans of the external mercury lamp do not have a direct influence on data products but are an important part of instrument characterization. Figure 5.1.9 illustrates the difference between internal and external mercury-lamp scans collected during the 2007 and 2008 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 by about 0.075 nm to shorter wavelengths. External scans have a bandwidth of about 1.01 nm FWHM. There is a small shift between the external scans from the 2007 and 2008 visits, which is likely caused by the increased wavelength uncertainty of measurements performed after November 2006. The bandwidth of the internal scan is 0.75 nm. External scans have the same light path as solar measurements and therefore represent the monochromator's bandpass at 297 nm that is relevant for solar scans.

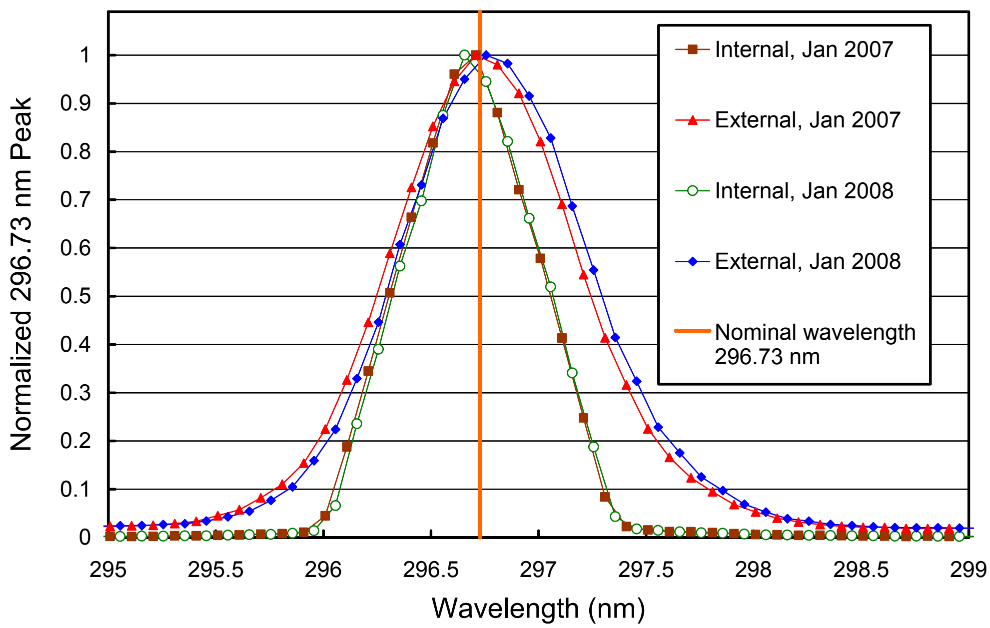

Figure 5.1.9 *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements. It is assumed that the wavelength registration of the monochromator did not shift between internal and external scans, which were close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

5.1.4. Missing Data

A total of 18808 scans are part of the McMurdo Volume 17 dataset. These are about 95.5% of the maximum possible number of data scans. 822 solar scans were superseded by calibration scans. Since McMurdo Station has 24 hours of sunlight per day during summer, a loss of solar data cannot be avoided. Only 31 scans were missed due to technical problems. A break-down of missing data is provided in Table 5.1.2

Table 5.1.2. Missing solar scans in the McMurdo Volume 17 data set.

Period	Number of scans	Reason
		Calibration scans
Throughout season	373	Response scans
Throughout season	342	Wavelength scans
Throughout season	107	Absolute scans
		Technical problems
03/02/07 – 03/03/07	23	No communication between PC and high-resolution analog to digital converted (HRAD)
Throughout season	8	Various
		Other
01/15/07 – 01/18/07	120	Site visit activities
01/21/07	10	Installation of Power Distribution Unit (PDU)

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 method outlined in Section 4.3.1.

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 17 data. For solar zenith angles smaller than 80°, measurements of the two instruments agree to within ±2.9% (±1σ). Data from the GUV-511 radiometer tend to be low for large SZAs. We advise data users to use SUV-100 rather than GUV-511 data when the Sun is low.

Figure 5.1.11 shows a comparison of total ozone measurements from the GUV-511 radiometer, the SUV-100 (Version 2 data set; see www.biospherical.com/NSF/Version2) 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 2.0% than OMI data. SUV-100 measurements are on average 2.8% larger than OMI observations. These offset are partly caused by the different treatment of the atmospheric ozone and temperature profiles in the inversion algorithms for the three data sets. GUV-541 ozone data become unreliable for SZA larger than 80° and should not be used.

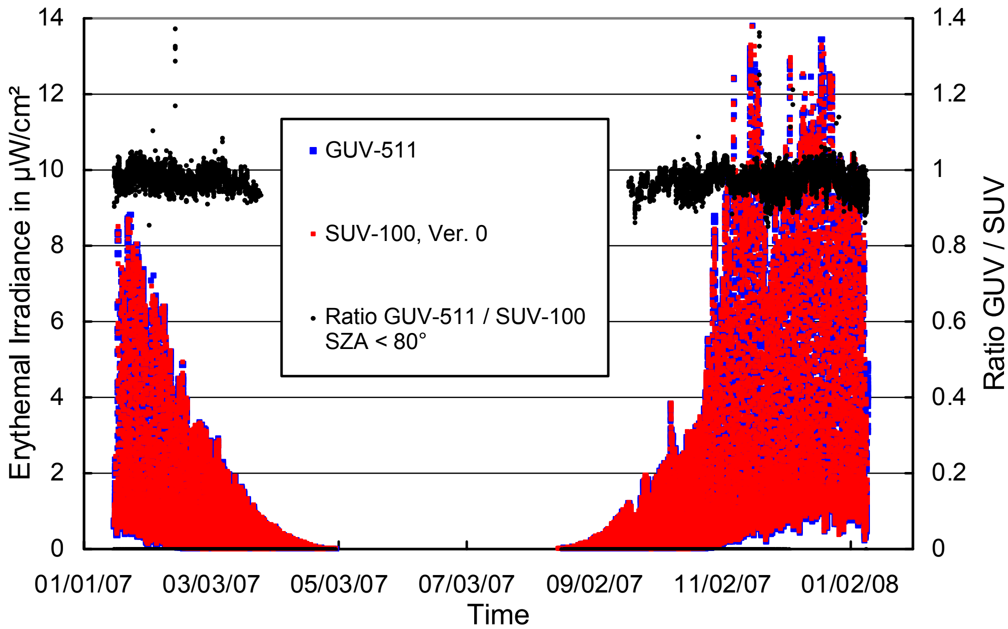

Figure 5.1.10. *Comparison of erythemal irradiance measured by the SUV-100 spectroradiometer and the GUV-511 radiometer. All data are based on "Version 0" (cosine-error uncorrected) data.*

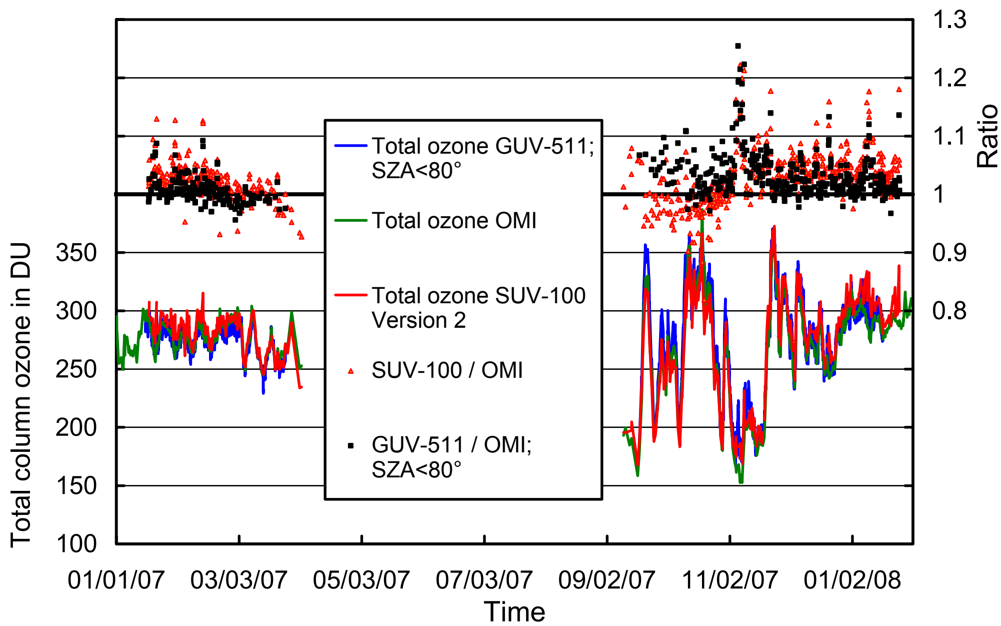

Figure 5.1.11. *Comparison of total column ozone measurements from GUV-511, SUV-100 (Version 2 data), and OMI (v8.5, Collection 3). GUV-511 and SUV-100 measurements are plotted in 15 minute intervals. For calculating the ratio of both data sets, only GUV-511 measurements concurrent with OMI overpass data were evaluated. The cause of the spike observed in ratios GUV/OMI and SUV/OMI between 11/5/07 and 11/9/07 is unknown.*