5.1. McMurdo Station (1/26/02 – 1/23/03)

The 2002/03 season at McMurdo Station is defined as the period between the site visits 1/22/02-1/26/02 and 1/23/03-1/29/03. The season opening and closing calibrations were performed on 1/25/02-1/26/02 and 1/23/03-1/24/03, respectively. Volume 12 solar data comprises the period 1/26/02 – 1/23/03. The system performed well during the entire period, with the following exceptions:

- **Drift of internal reference lamp**
  The system's internal reference lamp became brighter by about 8% during the season. This drift is larger than the 2-3% drift, which is usually observed. PMT currents monitoring the lamp changed by about 13%. The majority of this change can therefore be attributed to the drift of the reference lamp. The remaining 5% are like caused by changes in monochromator throughput or PMT sensitivity drifts. To compensate for these drifts, 6 different calibration files were applied during the Volume 12 period. A comparison of scans with the internal lamp and scans with the 200-W standards of irradiance indicates that the throughput of the system's entrance optics (cosine collector, relay lens, beam splitters) did not change. This is in contrast to observations from the previous season, when the system responsivity decreased steadily by 14% due to abrasion from the instrument's shutter (see 2001-2002 Operations Report). The shutter was replaced during the site visit in January 2002, and the problem disappeared.

- **Failure of digital multimeter**
  The SUV-100 system includes a digital multimeter that is used to set the lamp current during response and absolute scans. The instrument failed on 7/15/02 and was replaced by a spare on 7/16/02. As the failure occurred during Polar Night, published data are not affected. The spare multimeter was replaced by a new multimeter on 9/4/02.

- **Lost wavelength tracking of monochromator**
  Following a power outage on 12/25/02, the monochromator lost its wavelength position and scans between 12/25/02 and 12/27/02 were performed with a 80 nm wavelength offset. These scans could not be salvaged. After correcting the wavelength offset on 12/27/02, the monochromator mapping function was slightly different from the one observed before the power outage (see Section 5.1.3). A different wavelength correction function was therefore applied between 12/27/02 and 1/2/03. The accuracy of solar data from this period is not affected.

- **System time errors**
  The computer clock is daily adjusted by a GPS receiver. On 4/20/02 and 7/30/02, the time was erroneously reset by one day by the receiver. Solar data are not affected as the time was corrected before commencement of data scans following the reset.

- **UPS failure**
  The system's uninterruptible power supply (UPS) failed on 1/4/03. The UPS batteries were replaced on 1/8/03, which fixed the problem.

During the site visit in 2002, a Biospherical Instruments GUV-511 moderate-bandwidth filter radiometer was installed in close proximity to the collector of the SUV-100. The GUV instrument measures spectral irradiance at 305, 320, 340, and 380 nm, as well as photosynthetically active radiation (PAR). From these measurements, a total column ozone and a variety of biologically relevant dose-rates can be retrieved. The instrument is also a helpful tool for quality control of SUV-100 data. Figure 5.1.1 shows a comparison of erythemal SUV-100 and GUV-511 data. For solar zenith angles smaller than 75 degrees, both data sets typically agree to within ±5%. A comparison of GUV and SUV data revealed a problem in 26 data scans measured on 9/15/02 and 9/16/02, which were consequently discarded from the published SUV data set. More details of the GUV-511 radiometer can be found in Section 2. Volume 12 GUV data from McMurdo were calibrated by comparison with the SUV-100 spectroradiometer based on data from the period 11/16/02 – 11/28/02. GUV data is available for the period 3/6/02 – 1/13/03.

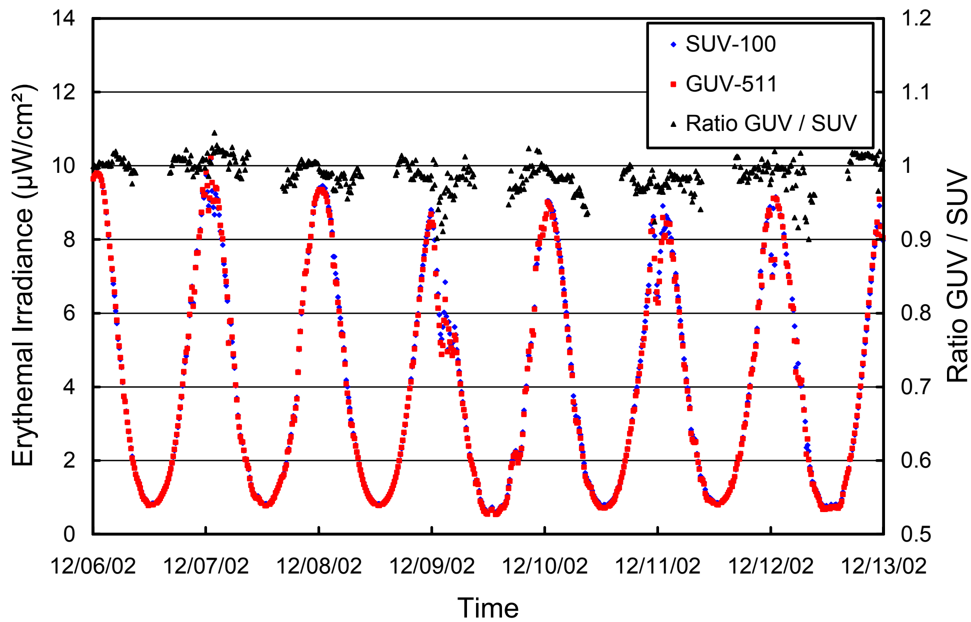

Figure 5.1.1. *Comparison of erythemal irradiance measurements performed with GUV-511 and SUV-100 in December 2002.*

The Eppley PSP and TUVR instruments installed at McMurdo were replaced by identical instruments during the site visit in January 2002. The PSP and TUVR radiometers installed during the Volume 12 period were both calibrated by Eppley Laboratory Inc. in November 2001. PSP solar data from Volume 12 are in good agreement with data from previous years. TUVR data appear to be somewhat higher than typical. We generally cannot confirm the calibrations provided by Eppley Laboratory Inc. We therefore advise data users to treat TUVR data as "uncalibrated," and use them for referential purposes only

5.1.1. Irradiance Calibration

The site irradiance standards for the 2002/03 McMurdo season were the lamps 200W005, 200W019, and M-543. Lamp M-764 was used as traveling standard. Its calibration was established by Optronics Laboratories in March 2001. Lamps 200W005 and M-543 were recalibrated by comparison with M-764 using scans performed during the site visits in 2001 and 2002 (see Section 4.2.1.5 for details of the procedure). Lamp 200W019 has an Optronics Laboratories certificate from September 1998, and was not recalibrated.

Figure 5.1.2 shows the Volume 12 season opening calibrations performed on 1/25/02 and 1/26/02. All site standards agree at the ±0.5% level. Figure 5.1.3 shows a similar comparison of all standards at the end of the season. Lamps M-543, 200W019, and M-764 agree to within ±0.5%. Measurements of lamp 200W005 are systematically high by 1.5%. Because of adverse weather conditions, calibration scans had to be interrupted for 15 hours. Scans with 200W005 were performed on 1/24/03 after the interruption whereas scans of all other lamps were conducted on 1/23/03. It is likely that a change in instrument sensitivity is the reason for the small discrepancy between measurements of 200W005 and the other lamps. Two comparisons between M-543, 200W005, and 200W019, performed mid-season (on 4/22/02 and 8/15/02) indicate a similar agreement between all lamps as during the opening calibrations depicted in Figure 5.1.2.

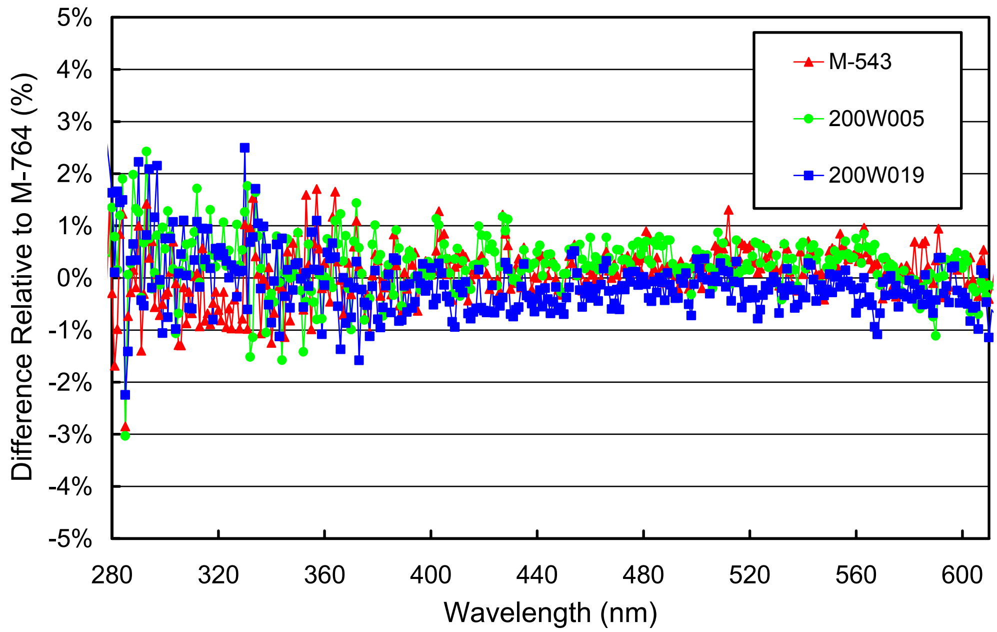

Figure 5.1.2. *Comparison of McMurdo lamps M-543, 200W005, and 200W019 with the BSI traveling standard M-764 at the beginning of the season (1/25/02-1/26/02).*

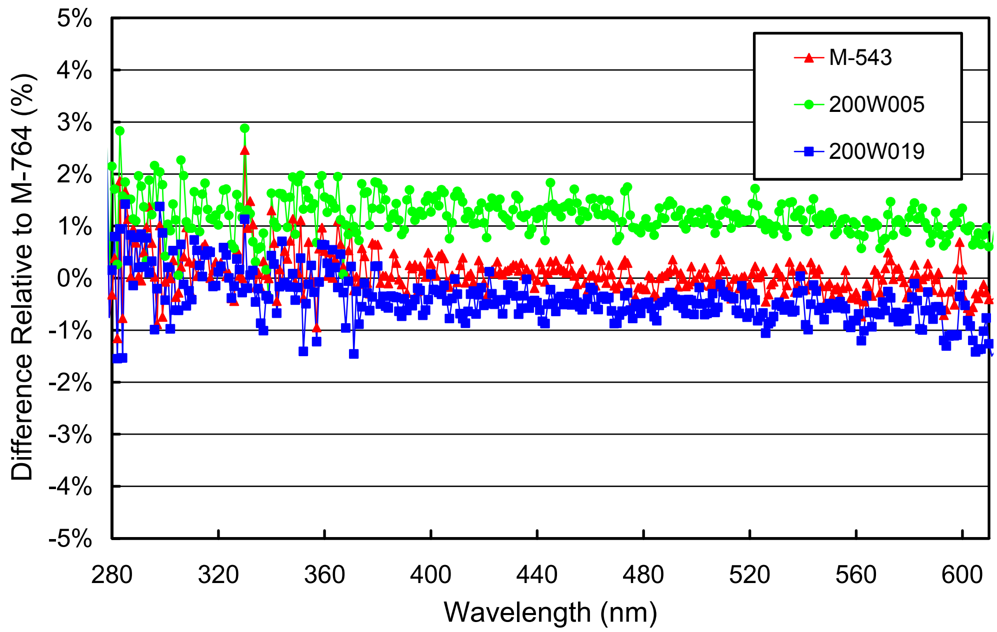

Figure 5.1.3. *Comparison of McMurdo lamps M-543, 200W005, and 200W019 with the BSI traveling standard M-764 at the end of the season (1/23/03-1/24/03).*

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 5.1.4 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 8% during the season. This change is somewhat larger than typical. PMT currents increased by approximately 12% over the same period. The larger part of this change can therefore be attributed to the brightening of the lamp. The remaining 4% are like caused by changes of monochromator throughput or PMT sensitivity. The dip in PMT currents during Polar Night has been observed during previous seasons. The reason of this cycle is unknown. The change in TSI readings and PMT currents observed between 7/16/02 and 7/29/02 is caused by the replacement of defective multimeter with the spare instrument. The calibration of the spare multimeter was not very accurate, causing the drop in the TSI and PMT measurements due to a reduced accuracy in setting the lamp current. After adjusting system parameters on 7/30/02 to compensate for the instruments calibration problem, TSI and PMT measurement compared well with data recorded prior to the multimeter failure. As the problem occurred during Polar Night, solar data are not affected.

The analysis of bi-weekly calibrations with the 200-W irradiance standards showed a change in system responsivity by 12% at 370 nm, in agreement with results from the response scans. This indicates that the throughput of the fore-optics (cosine collector, relay lens, beam splitters) did not change during the season.

The season was broken in six calibration periods to correct for the change in responsivity. In each of these periods, a different irradiance function was assigned to the internal lamp following the procedure described in Section 4.2.1.2. Figure 5.1.5 shows the ratios of those functions relative to the function applied in the first period (1/24/02-3/5/02). Period 2 refers to days between 3/5/02 and Polar Night, and Period 3 to days between Polar Night and 10/30/02. Period 4 ends on 11/20/02. Immediately after the calibration performed on this day, the instrument's cosine collector was removed and inspected for ice build-up. No ice was found, however, the inspection may have slightly changed instrument's responsivity. This may have contributed to the 2-3% difference in irradiance that was assigned to the internal lamp in Periods 4 and 5. The irradiance spectrum for Period 5 is based on one absolute scan only. A comparison of GUV and SUV data confirmed that the calibration applied during Period 5 is appropriate. Period 6 refers to days between 12/13/02 and the end of the season.

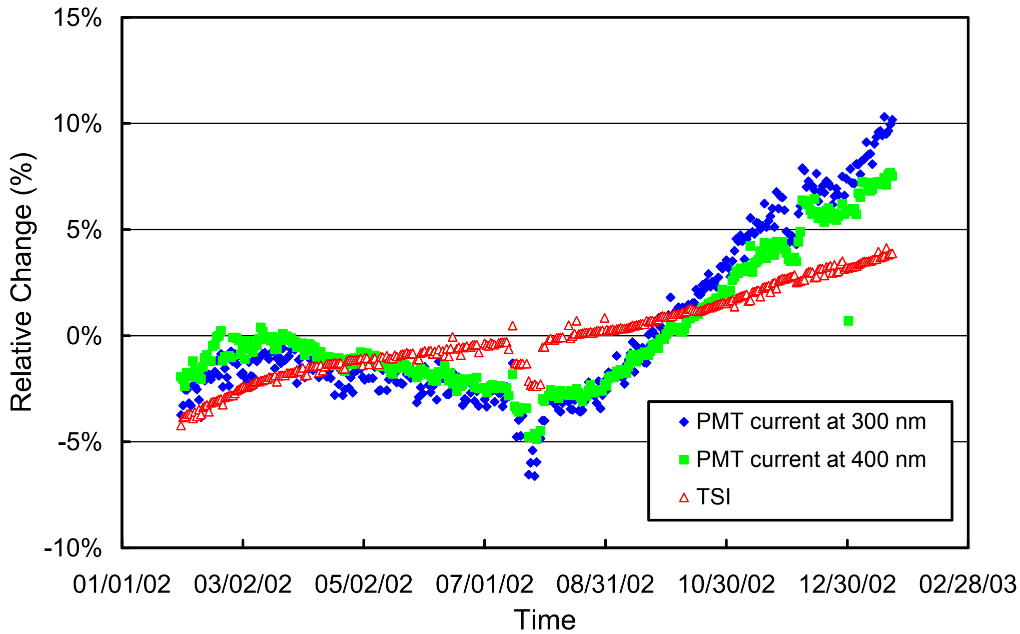

Figure 5.1.4. *Time-series of PMT current at 300 and 400 nm, and TSI signal during measurements of the internal irradiance reference lamp during the McMurdo 2002/03 season. The data is normalized to the average value of the whole season.*

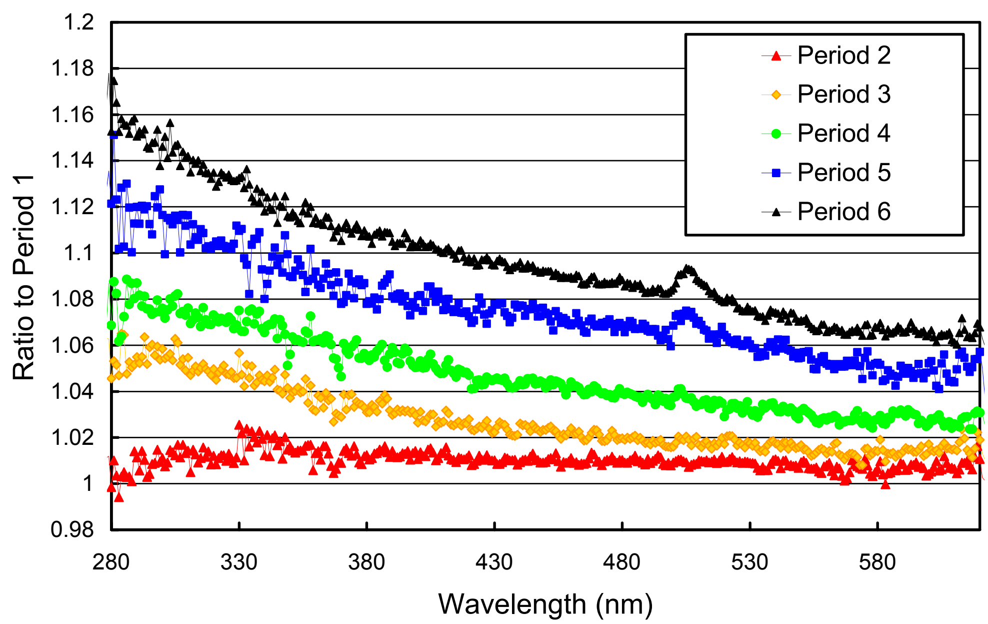

Figure 5.1.5 *Ratio of irradiance assigned to the internal reference lamp to the Period 1, 1/24/02-3/5/02.*

Figure 5.1.6 presents the ratios of the standard deviations and average spectra, calculated from the individual absolute scans of each period. These ratios 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 good stability within a given period.

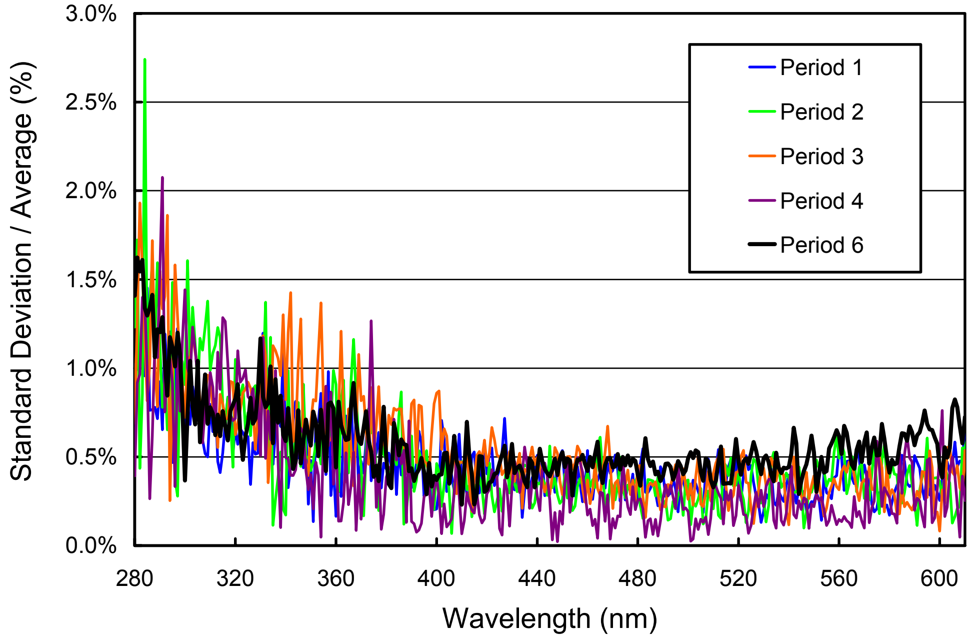

Figure 5.1.6. *Ratio of standard deviation and average calculated from the absolute calibration scans.*

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 5.1.7 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 388 pairs of scans have been evaluated. For 91% of the days, the offset change is smaller than ±0.025 nm; for 99% of the days it is smaller than ±0.055 nm. The offset-difference is only larger than ± 0.1 nm for 2 scans when the wavelength was manually adjusted. The wavelength calibration of the final data was corrected accordingly.

After the 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 Fraunhofer-correlation method, as described in Section 4.2.2.2. Two correction functions were applied (Figure 5.1.8) One function covers almost the entire season, except of a short period between 12/27/02-1/2/03. Immediately before this period, the monochromator lost its wavelength position due to a power outage, which was not bridged by the UPS. The system was scanning with a 80 nm wavelength offset for several hours. After the correction of the wavelength offset, the monochromator wavelength mapping had somewhat changed (in particular between 310 and 350 nm) before it gradually returned to the mapping that was observed before the power outage. By implementing a different correction function for the affected period, wavelength shifts in solar data were minimized.

After the data was wavelength corrected using the shift-function described above, the wavelength accuracy was again tested with the Fraunhofer method. The results are shown in Figure 5.1.9 for four UV wavelengths. The residual shifts are typically smaller than ±0.05 nm. There is more scatter at 310 nm shortly before and after polar night, because of the small solar irradiance levels that prevail during this part of the year. The wavelength stability is not worse during this time; yet the correction algorithm is less precise.

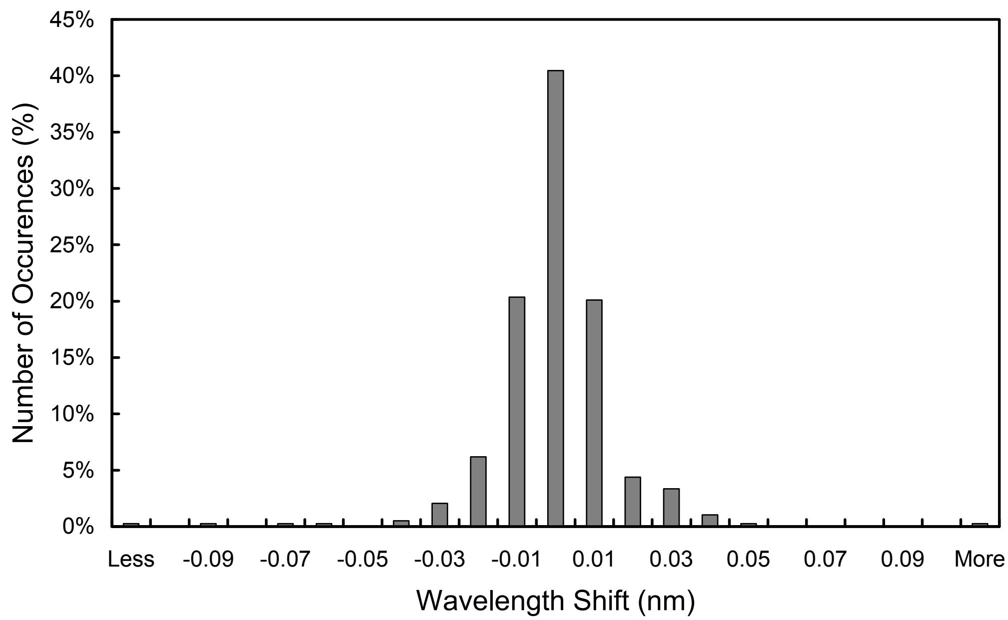

Figure 5.1.7. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

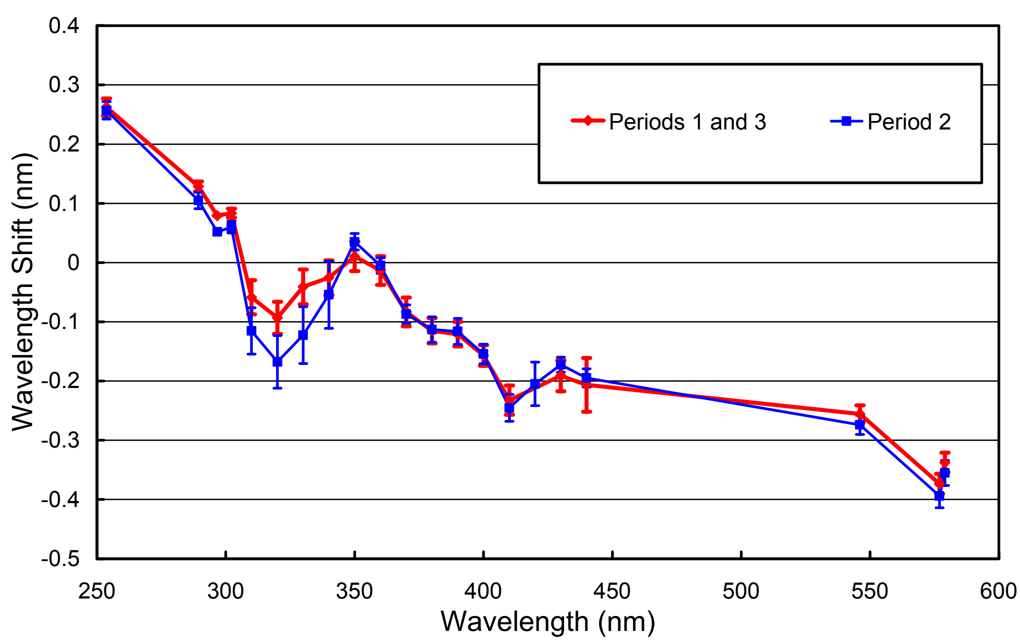

Figure 5.1.8. *Monochromator non-linearity correction functions for McMurdo 2002/03 data. The functions were calculated with the Fraunhofer-correlation method. Period 1 covers the period 1/24/02-12/26/02, Period 2 is 12/27/02-1/2/03 and Period 3 is 1/3/03-1/25/03.*

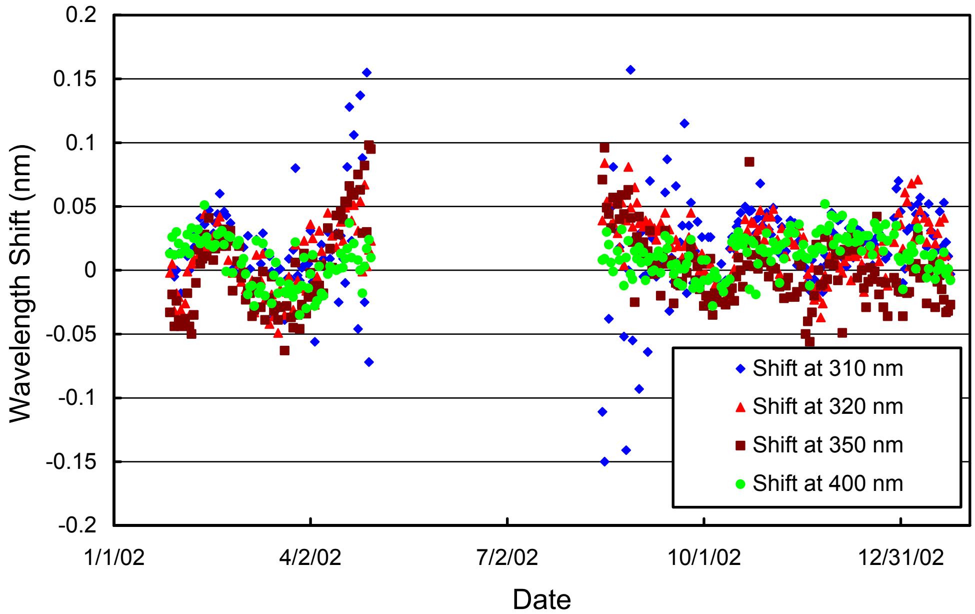

Figure 5.1.9. *Check of the wavelength accuracy of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season. No correlation data is available during the polar night.*

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 5.1.10 illustrates the difference between internal and external mercury scans collected during both 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 0.08 nm to shorter wavelengths. External scans have a bandwidth of about 1.03 nm FWHM. The bandwidth of the internal scan is 0.75 nm. Since external scans have the same light path as solar measurements, they more realistically represent the monochromator bandpass relevant for solar scans. The scans at start and end of the season are very consistent.

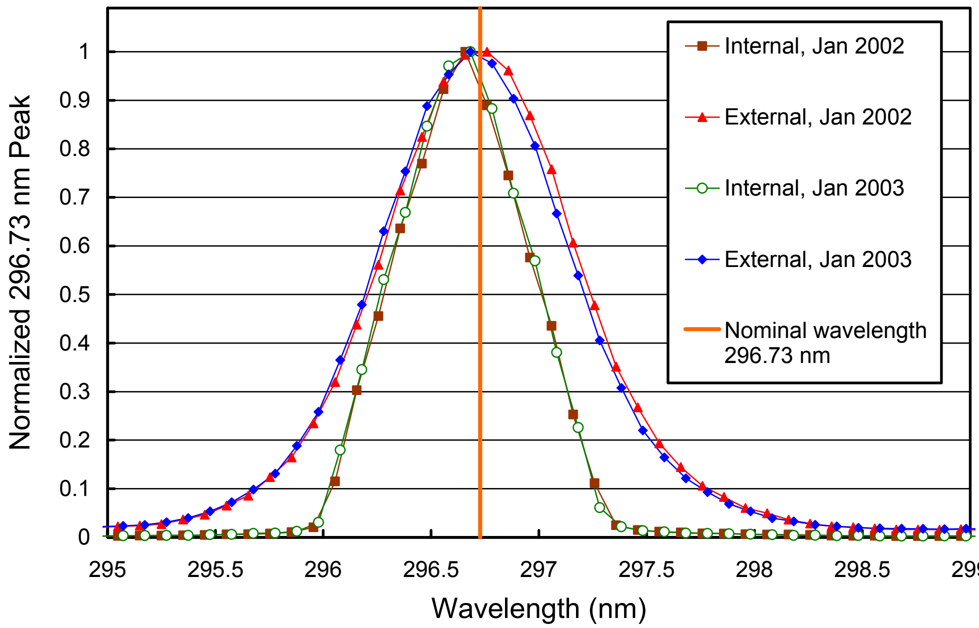

Figure 5.1.10 *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements, i.e., it is based on a combination of internal scans and the Fraunhofer-correlation method. It is assumed that the wavelength registration of the monochromator did not shift between internal and external scans, which were close in time.*

5.1.4. Missing Data

A total of 17533 scans are part of the published McMurdo Volume 12 dataset. These are 95% of the scans scheduled. Only 0.7% of all scans were missed due to technical problems. Of all missing data scans, 145, 327, and 314 were superseded by absolute, wavelength, and response scans, respectively. Following a power outage on 12/25/02, the monochromator lost its wavelength position and scans between 12/25/02 and 12/27/02 were performed with a 80 nm wavelength offset. A total of 121 scans could not be salvaged and were excluded from the data set. 26 scans measured on 9/15/02 and 9/16/02 were found to be defective and were also excluded. In addition, replacement of the Eppley PSP and TUVR instruments lead to a loss of 4 scans on 1/27/02. Installation of the GUV instrument and its logging software on 1/28/02 superseded 7 scans.