5.1. McMurdo Station (1/28/99 – 1/30/00)

The 1999-2000 season at McMurdo Station is defined as the time between the site visits 1/20/99 – 1/27/99 and 1/30/00-2/7/00. The season opening and closing calibrations were performed on 1/24/99 and 1/31/00, respectively. Volume 9 solar data comprises the period 1/28/99 – 1/30/00. The system operated normally during this time, except between 2/26/99 and 3/6/99 when the wavelength position indicator of the monochromator jammed. The system was removed from the roofbox in response to the problem, the indicator was replaced, and the system was reinstalled on 3/5/99. No data from the affected period is published. The wavelength mapping of the monochromator changed slightly due to system service and different wavelength correction functions were therefore applied before and after the service period. Absolute scans confirmed that the irradiance values assigned to the internal reference lamp did not require adjustment despite of the removal of the instrument.

During the entire Volume 9 period the system responsivity remained stable to within ±4%. This uncertainty was further reduced using the daily scans of the internal lamp. About 93% of the scheduled data scans are part of the published dataset; about 4% of all scans were lost because of technical problems.

On 11/10/99, the time was set incorrectly by the GPS unit; data scans between 11/10/99 12:00 and 11/11/99 11:30 were recorded with a one-day time-shift. The time-error was corrected during data analysis; time and solar zenith angle fields of the published composite scans and databases are correctly aligned with the irradiance values. The filenames of the composite scans and the field “DataScan” in the databases, however, were not adjusted, since the filename is the key field of our internal data structure. Therefore, the data scan AD991200.313 (i.e. the first scan that is affected) includes the measurement at 11/10/99 12:00 rather than 11/9/99 12:00.

During the site visit in January 2000, the PSP and TUVR instruments installed at McMurdo were replaced by identical instruments, which had been calibrated recently by Optronic Laboratories. The previous set of instruments was sent to Optronics Laboratories for recalibration. The new calibration factors were applied to the data in the Volume 9 season. These factors are presumably more accurate than the old factors that were established 1988. For the TUVR, new and old factors are identical. New and old factors for the PSP, however, deviate by 4.2%. The direction is such that irradiance values calculated with the new factor are higher.

5.1.1. Irradiance Calibration

The site irradiance standards for the 1999-2000 McMurdo season were the lamps 200W005, 200W019, and M-543. Lamp M-874 was used as traveling standard. It was calibrated by Optronic Laboratories in September 1998. Lamps 200W005 and 200W019 have Optronic Laboratories certificates from November 1996 and September 1998, respectively. Lamp M-543 does not have a calibration from an independent standards laboratory. For use in the 1999-2000 season, the lamp was calibrated by comparison with M-874 using data centered around the 1999 site visit. Lamp M-543 appeared to be less stable than the two other site standards. Only one absolute scan of this lamp was used from the first part of the season, when the lamp was still stable.

Figure 5.1.1 shows a comparison of all lamps at the beginning of the season (1/24/99). All lamps generally agree on the ±1% level, with slightly larger deviations below 300 nm. Figure 5.1.2 shows a similar comparison of all lamps at the end of the season. Lamps 200W005 and 200W019 agree almost perfectly but there is a systematic difference of 1-2% to M-874. This disagreement is still within the uncertainty specifications of calibration standards.

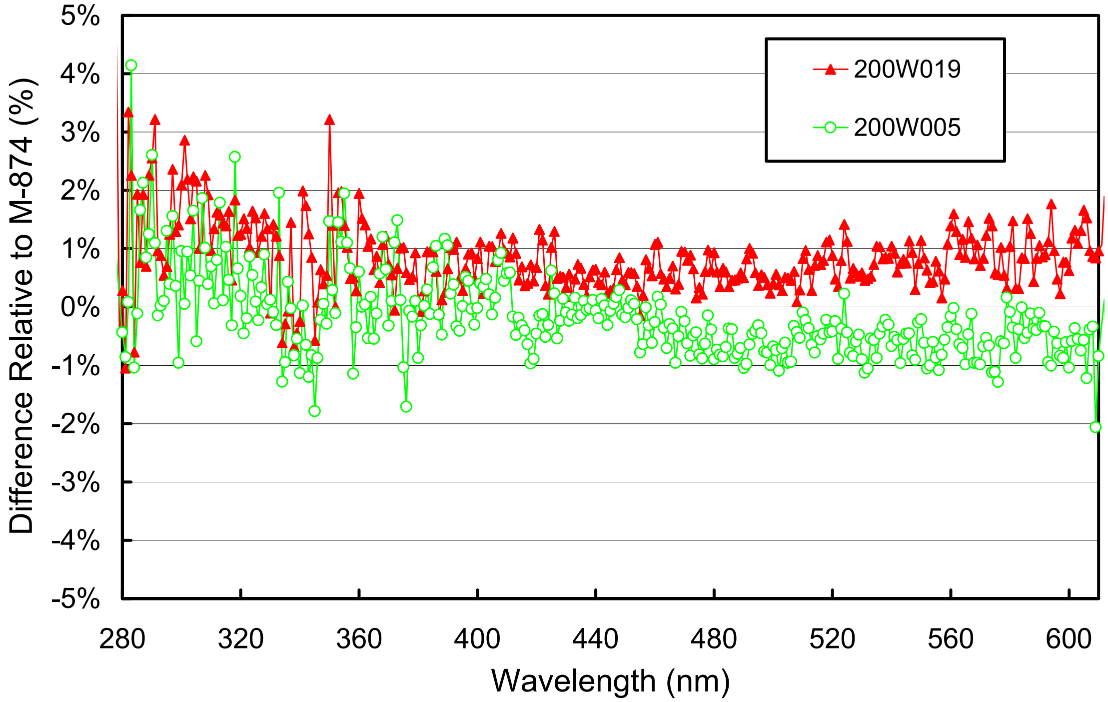

Figure 5.1.1. *Comparison of McMurdo lamps 200W005 and 200W019 with the BSI traveling standard M-874 at the beginning of the season (1/24/99).*

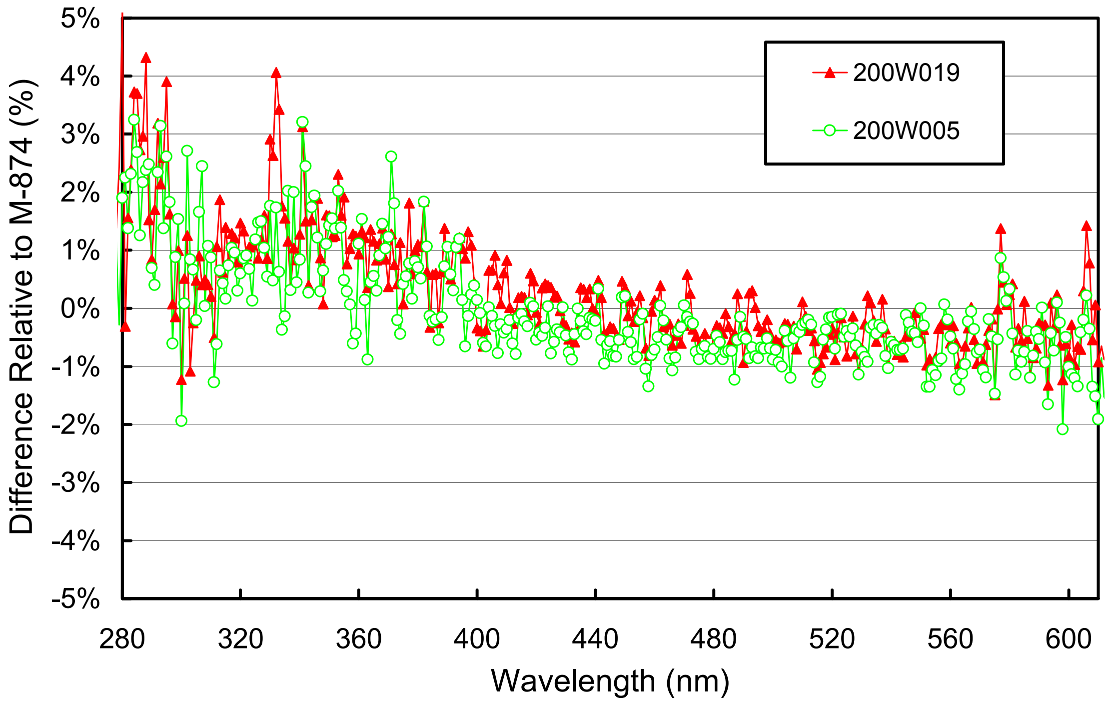

Figure 5.1.2. *Comparison of McMurdo lamps 200W005 and 200W019 with the BSI traveling standard M-874 at the end of the season (1/31/00).*

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. The stability of the internal lamp itself 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 the instrument responsivity 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 of the McMurdo 1999-2000 season. TSI measurements fluctuate by less than ±1% during the whole season, indicating stability of the internal lamp. PMT currents change by 2% between 2/25/99 and 3/6/99. During this time, the system was removed from the roofbox for replacement of the monochromator's wavelength indicator. Between March and August 1999, system responsivity decreased by approximately 3% before it increased by 5% between August 1999 and the end of the season. Note that this annual cycle has also been observed during the 1997-98 and 1998-99 seasons and could be attributable to variations in instrument temperature. The actual reason is unknown, though. The change in instrument responsivity does not affect solar data because the daily response scans are not performed exclusively for monitoring drifts, but also for correcting these drifts. Day-to-day changes, which would affect solar data, are below 0.5%.

The relative difference of signals from internal and external lamp scans was virtually the same before and after the monochromator service, despite the observed change in overall system responsivity mentioned above, which affected internal and external scans equally. The spectral irradiance assigned to the internal lamp was therefore the same before and after the break point. However, the wavelength mapping of the monochromator did slightly change, and therefore a new wavelength correction function was applied from 3/6/99 onward (dashed line in Figure 5.1.3).

Although the internal lamp was stable, calibrations with the 200-Watt site standards suggested that the accuracy of the instrument calibration can be increased by splitting the season in two periods, denoted Periods 1 and 2. The irradiance assigned to the internal lamp was calculated separately for both periods following the procedure described in Section 4.2.1.2. Figure 5.1.4 shows the ratio of the irradiance assigned to the internal lamp Period 2 / Period 1. It deviates less than 2% from unity. Figure 5.1.5 presents the ratio of the standard deviation and average spectra, calculated from the individual spectra of each period. This ratio is useful for estimating the variability of the calibrations in each period. As can be seen, the variability in Period 1 is very similar to that of Period 2, despite of the monochromator service in the middle of Period 1. For both periods is the standard deviation usually less than 1%, except below 300 nm.

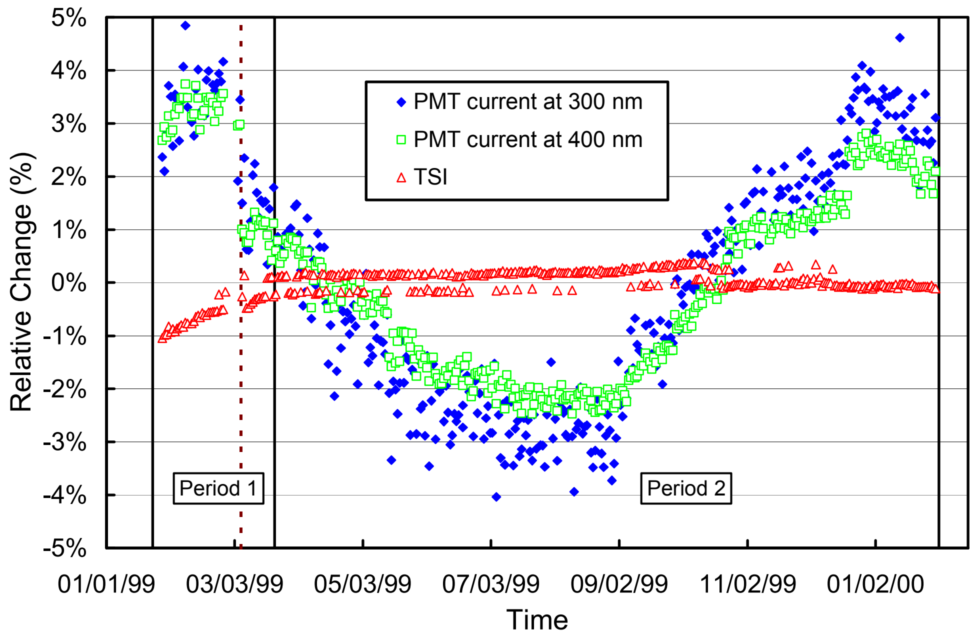

Figure 5.1.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal during measurements of the internal irradiance reference lamp during the McMurdo 1999-2000 season. The data is normalized to the average value of the whole season. The dashed line indicates the day when the wavelength correction table was changed.*

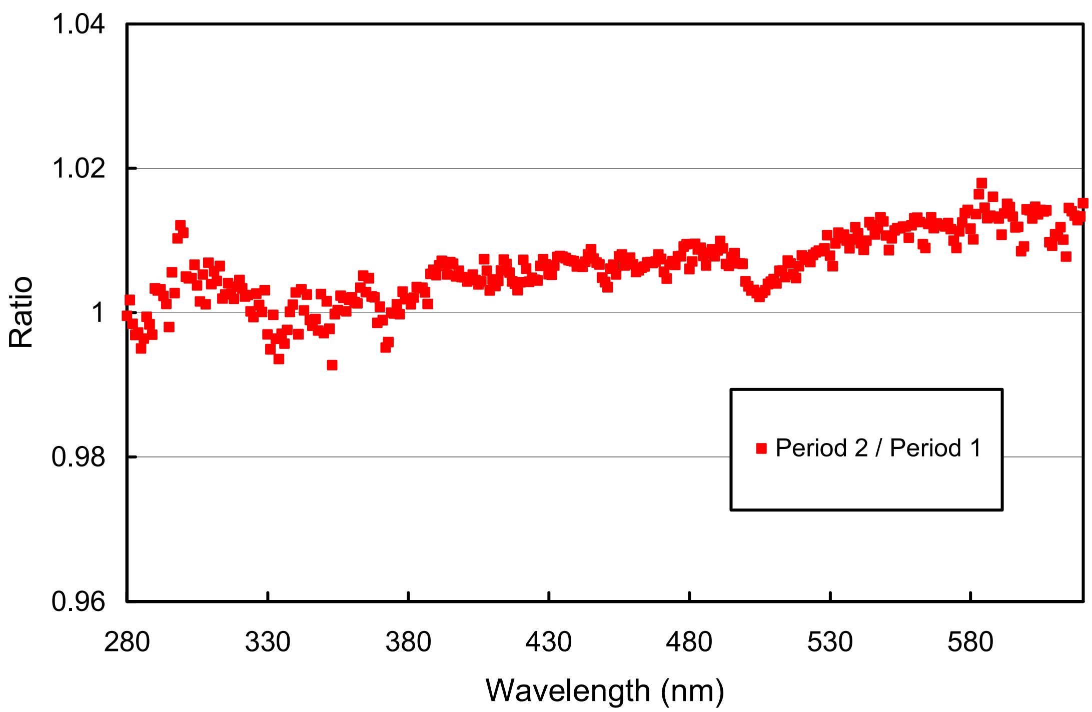

Figure 5.1.4 *Ratio of irradiance assigned to the internal reference lamp.*

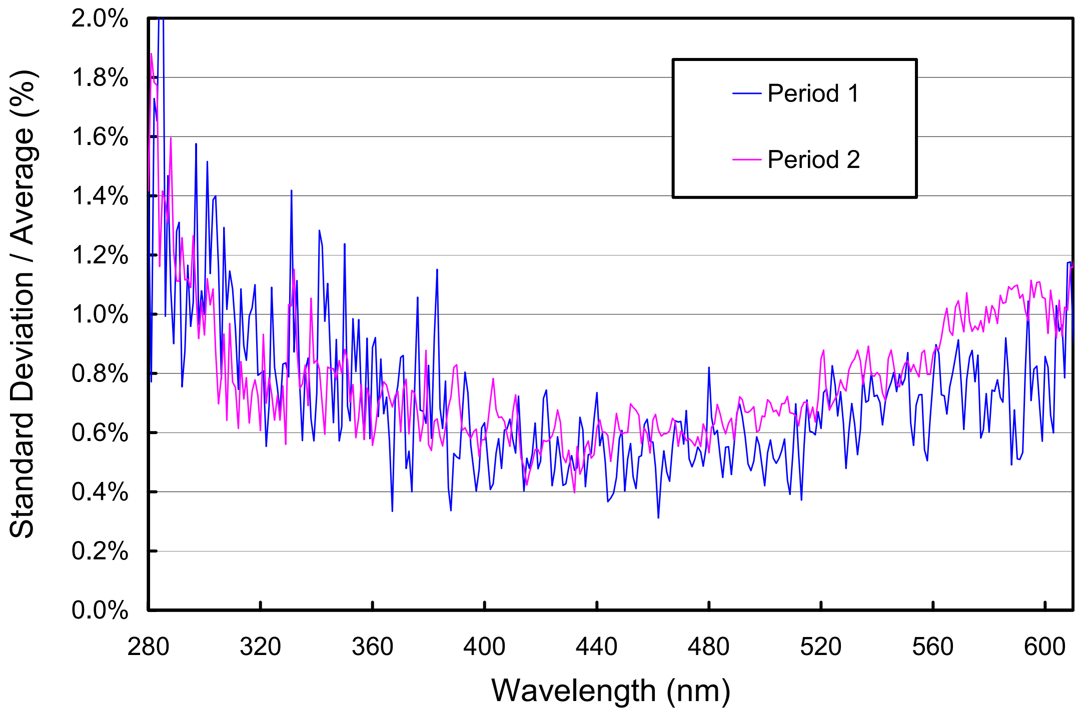

Figure 5.1.5. *Ratio of standard deviation and average calculated from the absolute calibration scans measured during the McMurdo 1999-2000-season.*

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, 381 scans have been evaluated. For 86% of the days, the change in offset is smaller than ±0.025 nm; for 98% of the days the shift is smaller than ±0.075 nm. The offset-difference is larger than ± 0.1 nm for 6 scans, performed between 2/25/99 and 3/6/99. This is the period when the monochromator dial was serviced. Scans during this period were not published.

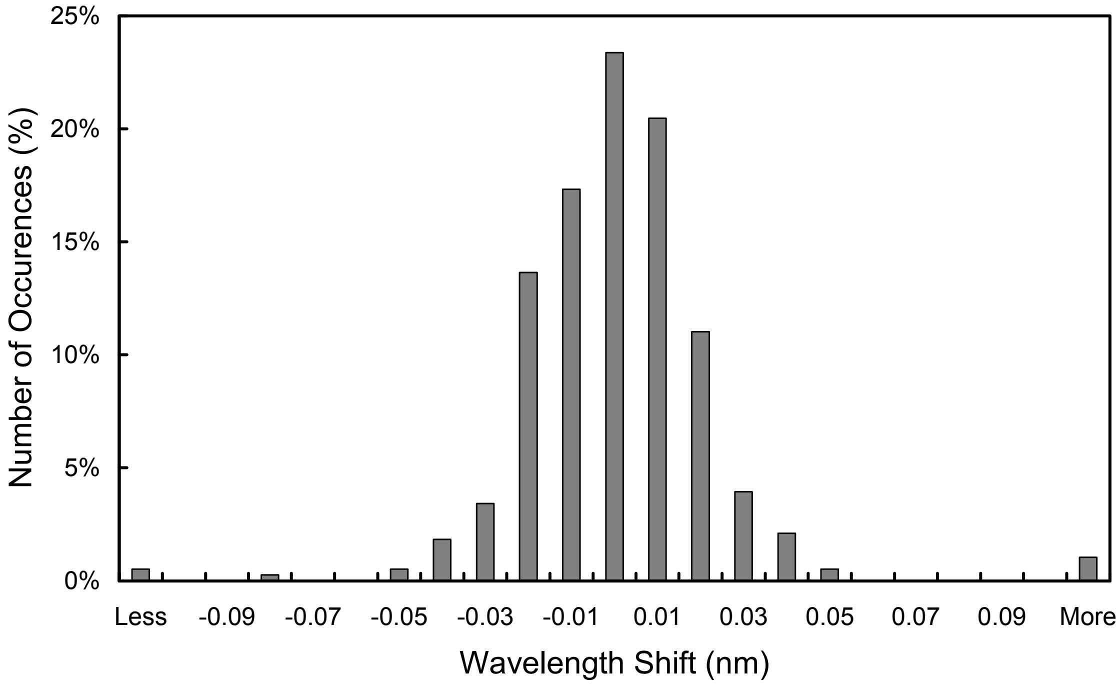

Figure 5.1.6. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means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

After 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. Due to the service to the monochromator, two correction functions were established. One was used from the beginning of the season until 3/5/99 (Period A). The second function was implemented from then onward to the season end (Period B). Both functions are shown in Figure 5.1.7. The functions clearly depend on wavelength, which is caused by inherent non-linearities in the monochromator drive. Both functions are very similar, suggesting that the service only slightly affected the monochromator's wavelength mapping. In order to demonstrate the difference between the result of the Fraunhofer-correlation method and the method that was historically applied, Figure 5.1.7 also includes a correction function that was calculated with the "old" method, i.e., the function is based on internal wavelength scans only. The average difference between both approaches is about 0.14 nm. As explained in Section 4.2.2, this bias is caused by the different light paths for internal wavelength scans and solar measurements.

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 5.1.8 for four UV wavelengths. The residual shifts are generally smaller than ±0.1 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. The monochromator service manifests itself by the change in the pattern of the residual shift beginning of March 1999.

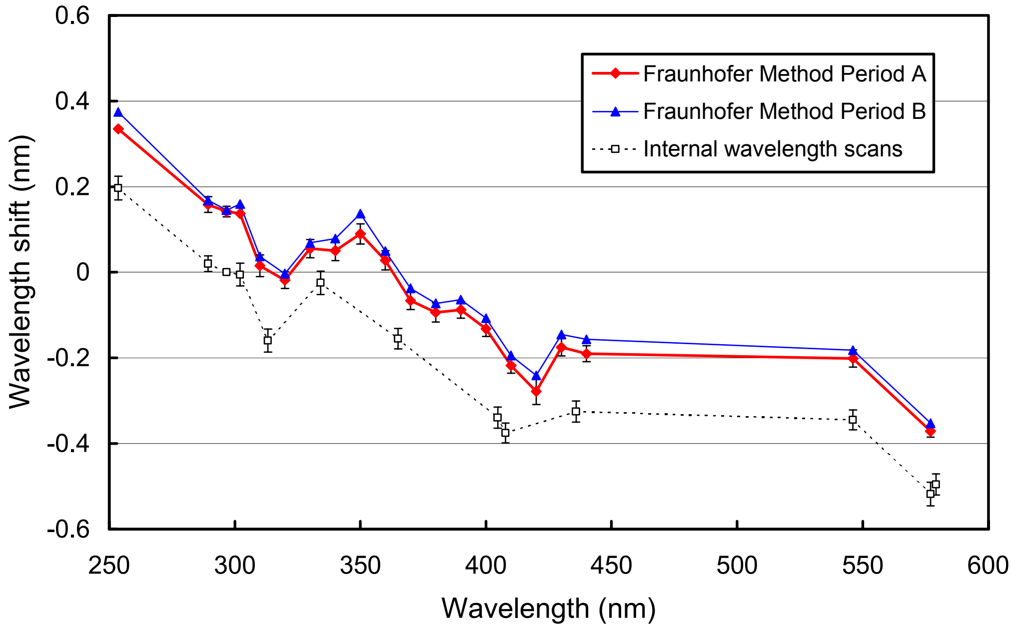

Figure 5.1.7. *Monochromator non-linearity for the McMurdo 1999-2000 season. Lines: Correction functions calculated with the Fraunhofer-correlation method for Periods A and B. Broken line: Correction function calculated with the method that was historically applied. The offset difference between both methods is 0.14 nm. The error bars show the 1σ standard deviation of the wavelength shift.*

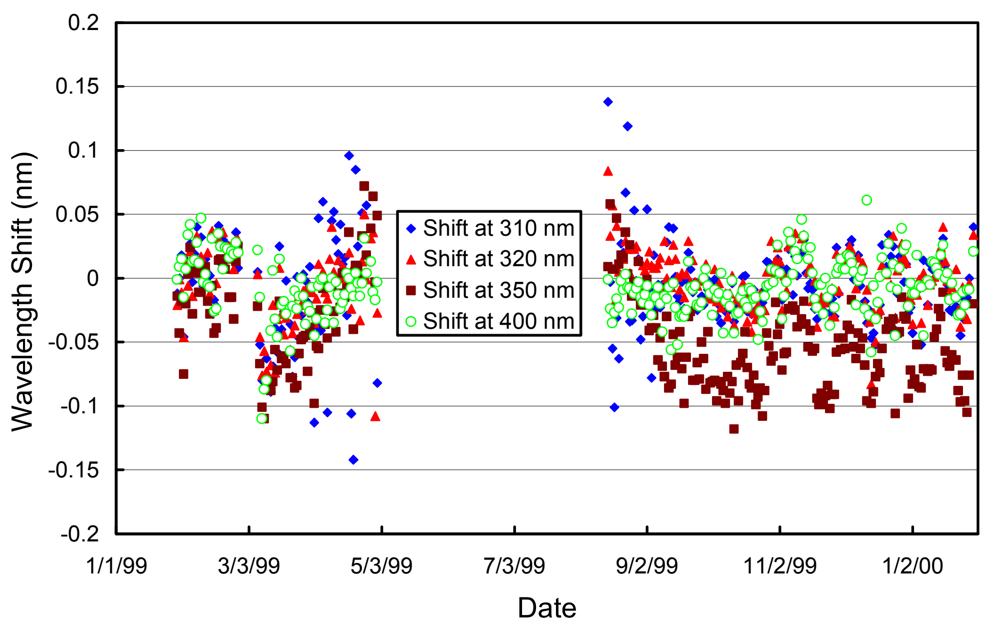

Figure 5.1.8. *Check of the wavelength accuracy of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season. No correlation data is available during the polar night.*

Data from the external mercury scans do not have a direct influence on the 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 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 0.15 nm to shorter wavelengths. External scans have a bandwidth of about 1.02 nm FWHM. The bandwidth of the internal scan is only 0.71 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 the start and end of the season are very consistent.

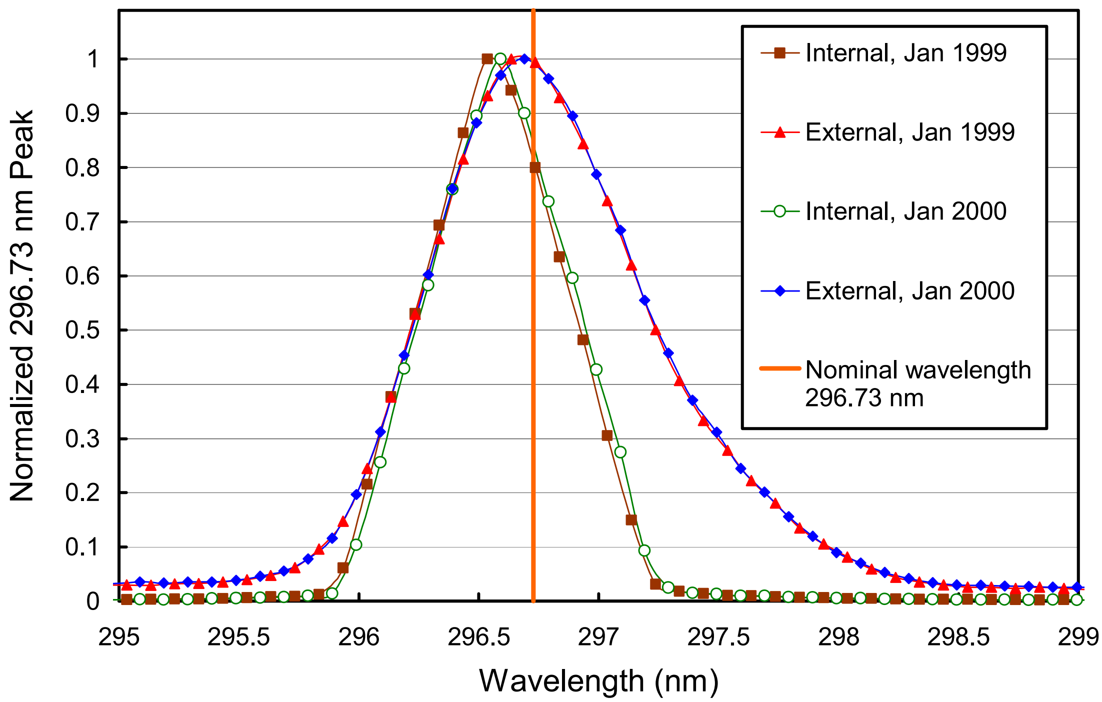

Figure 5.1.9 *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements, i.e., it is based on a combination of internal scans and the Fraunhofer-correlation method. It is assumed that the wavelength registration of the monochromator did not shift between internal and external scans, which were close in time.*

5.1.4. Missing Data

A total of 17589 scans are part of the published McMurdo Volume 9 dataset. These are 93% of the scans scheduled. Approximately 4.4% of all scans were missed due to technical problems. Of all missing scans, 81, 146, and 259 were superseded by absolute, wavelength, and response scans, respectively. Between 2/26/99 and 3/6/99, the wavelength position indicator of the monochromator jammed and the system was repaired. A total of 657 scans (3.5%) were lost due to this problem. Because of a wrong computer time setting, which was caused by an incorrect GPS readout, 97 scans were not recorded on 11/10/99 and 11/11/99. A problem with the software's scan scheduling module prevented the measurement of the first 19 scans on 12/20/99. Due to the same reason, 50 scans on 1/21/00 and 10 scans on 1/29/00 are missing.