5.2. Palmer Station (3/19/00 – 5/17/01)

The 2000-2001 season at Palmer Station is defined as the time between the site visits 03/09/00 - 03/19/00 and 5/18/01 – 5/25/01. The season opening and closing calibrations were performed on 3/18/00 and 5/18/01 and 5/24/01, respectively. Volume 10 solar data comprises the period 3/19/00 – 5/17/01. During the site visit in 2000, the collector of the instrument was modified. This upgrade resulted in substantially decreased azimuth errors, which affected solar data of previous volumes, see the introduction to Chapter 5. In addition, the relay lens of the optics block (see Figure 2.1 of Chapter 2) was replaced with a lens of larger focal length, leading to a higher system sensitivity. This gain in sensitivity compensates for the reduction in sensitivity due to the collector upgrade.

A new PMT cooler power supply was installed during the 1999 site visit. Compared to its predecessor, the temperature regulation is more accurate, which is accomplished via a switching PID controller. The switching unfortunately introduced excess noise in the PMT current due to a ground loop. For solar elevations higher than 20° and wavelengths below 345 nm, the detection limit[1] during Volume 9 was approximately 0.003 $\mu W\ cm^{-2}\ nm^{-1}$, which is by a factor of three higher than the typical value 0.001 $\mu W\ cm^{-2}\ nm^{-1}$. The detection limit for solar elevations below 20° was approximately 0.0007 $\mu W\ cm^{-2}\ nm^{-1}$, which is only slightly above the normal value of 0.0005 $\mu W\ cm^{-2}\ nm^{-1}$. The noise has been reduced during the site visit in 2000 by improving the ground connection of the PMT. Following the site visit, noise levels were down to 0.0023 $\mu W\ cm^{-2}\ nm^{-1}$ for solar elevations above 20°, and 0.0004 $\mu W\ cm^{-2}\ nm^{-1}$ for solar elevations below 20°. On 01/11/01, a change of the temperature set point of the PID controller brought noise levels back to normal, i.e. 0.0012 µW cm-2 nm-1 for solar elevations above and 0.0003 µW cm-2 nm-1 below 20° solar elevation. The effect of the problem on published dose-rates is almost negligible because signal levels in the relevant spectral regions are well above the increased noise level, except when solar elevation is below 2°.

It was found during the site visit in 2000 that the value of the shunt, which controls the current supplied to calibration lamps, deviated from its target value of 0.01Ω by 0.2%. Because of this deviation, lamp currents were too low by 0.2%. This is not negligible because a difference of 0.2% in the current translates into a 1-2% difference in the standard lamps' irradiance. The problem was solved during the site visit, and lamp currents applied during Volume 10 calibrations were within specifications. However, solar measurements during Volume 9 may have been too high by 2% in the UVB and 1% in the visible. Since this cannot be proven, no corrections were applied.

During the site visit in March 2000, the PSP instruments was replaced by an identical instrument, which had been calibrated by Eppley before the site visit. The previously installed PSP was sent to Eppley for recalibration.

About 98% of the scheduled data scans are part of the published dataset; less than 1% of all scans were lost because of technical problems.

5.2.1. Irradiance Calibration

The site irradiance standards for the 2000-2001 Palmer season were the lamps 200W007, M-765, and M-700. Lamp M-874 was used as the traveling standard at the beginning of the season and lamp M-764 was the traveling standard at the season's end. In addition, lamp 200W017, which is a new lamp calibrated by Optronic Laboratories in March 2001 was used.

[1] Detection limit is defined as the standard deviation of the measured spectral irradiance at 285 nm. At this wavelength, all solar radiation is filtered out by the Earth's ozone layer. The measured value at 285 nm therefore reflects the magnitude of instrument noise, which causes the detection limit.

Lamp 200W007 has an irradiance calibration from Optronic Laboratories from November 1996. Lamp M-765 has an Optronic Laboratories calibration from 1992 and has been in use at Palmer Station since 1992. The lamp was recalibrated with M-874 using data from the Volume 9 opening calibrations. Lamp M-700 was calibrated in a similar fashion as lamp M-765; the irradiance calibration was transferred from the traveling standard M-874 using absolute scans of both lamps from days 5/11/99 and 5/12/99. The calibrations of all three site standards was the same as in Volume 9. The traveling standard M-874 became unstable during the second half of 2000 and was therefore used only during the season opening calibrations (see also the introduction to Chapter 5), when Optronic Laboratories calibrations from September 1998 were used. M-764 was originally calibrated by Optronic Laboratories in 1992 and recalibrated in March 2001, shortly before the season closing calibrations.

Figure 5.2.1 shows the Volume 10 season opening calibrations performed on 3/18/00. All site standards agree on the ±1% level, but there is a bias of 1-2% compared to the calibration of the traveling standard M-874. This bias is most like due to M-874, which showed a drift from the time of the Palmer site visit onward.

Figure 5.2.2 shows the Volume 10 season closing calibrations performed between 5/18/01 and 5/24/01. All lamps agree with M-764 to within ±1%, giving confidence in the irradiance scale applied to Palmer Volume 10 solar data.

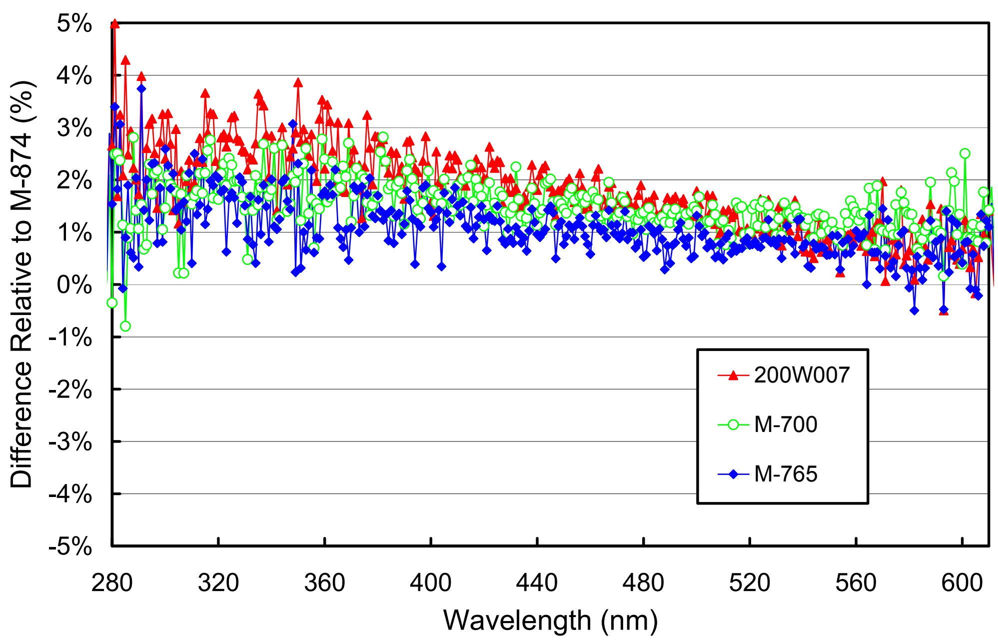

Figure 5.2.1. *Comparison of Palmer lamps 200W007, M-700, and M-765 with the BSI traveling standard M-874 at the beginning of the season.*

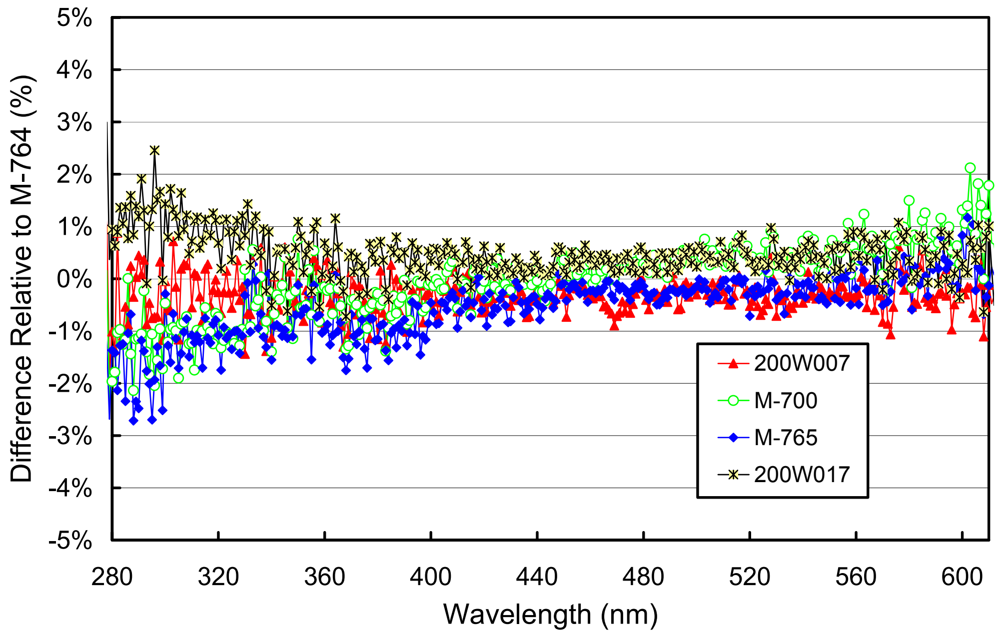

Figure 5.2.2. *Comparison of Palmer lamps 200W007, M-700, and M-765 with the BSI traveling standard M-764 at the end of the season (5/18/01 - 5/24/01).*

5.2.2. 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 5.2.3 shows the changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily response scans of the Palmer 2000/01 season. The TSI measurements indicate that the internal lamp was stable to within ±1%; PMTcurrents were stable to within ±3.5%. The one-percent change in all measures occurring on 2/10/01 was due to a power outage.

Although analysis of the response scans suggested good stability of the system, absolute calibrations with 200-Watt lamps indicated changes at wavelengths below 330 nm. Above this wavelength, calibrations performed throughout the season were stable to within ±2.5%. The larger variability in the UV-B might have been caused by an absorbing substance in the instrument's optical path, which gradually evaporated during the season. The real reason is unknown. Because of this variability, eight different periods were introduced with a different irradiance spectrum assigned to the internal irradiance standard in each period. Figure 5.2.4 shows the ratio of these spectra, referenced to the first spectrum. All eight spectra are the average of calibration scans performed in a given period. In addition, the standard deviation of the individual spectra contributing to an average spectrum were calculated. Figure 5.2.5 shows the ratio of the standard deviation and average spectra. The ratios are useful for estimating the variability of the calibrations in each period. Figure 5.2.5 shows that the standard deviation is usually less than 1% of the average for all periods in the UV-A and visible, and increases slightly towards shorter wavelengths. Thus the calibrations in all periods are consistent to the ±1% (±1σ) level. However, the change from one period to the next may be as large as 4% for wavelengths in the UV-B (compare for example the curves for Period 7 and 8 in Figure 5.2.4). The calibration uncertainty for some periods is therefore increased. Note that the system was very stable during Period 8, which includes the period October 2000 – May 2001.

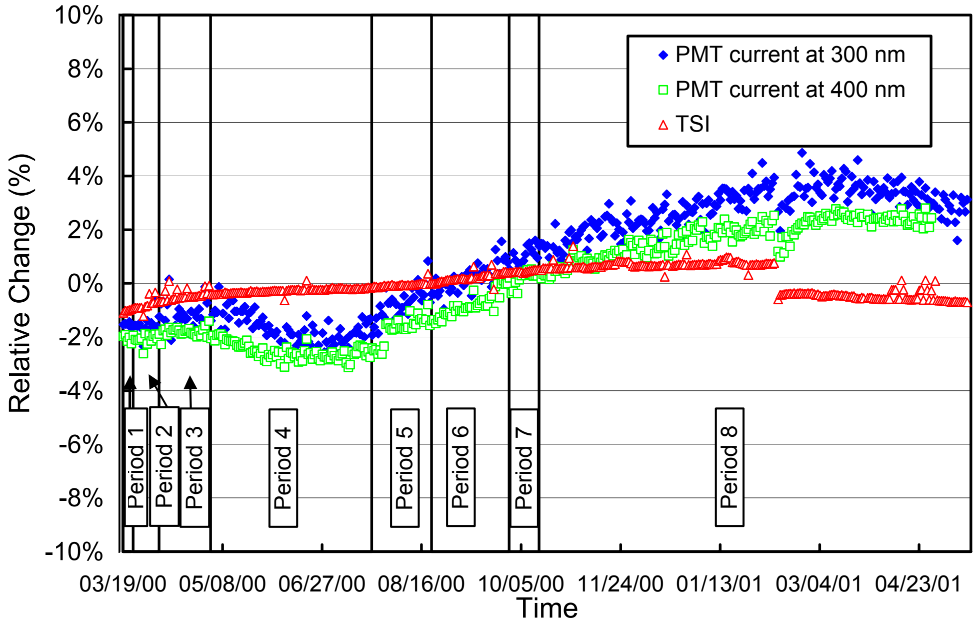

Figure 5.2.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal during measurements of the response lamp during the Palmer 2000/01 season. The data is normalized to the average of all periods.*

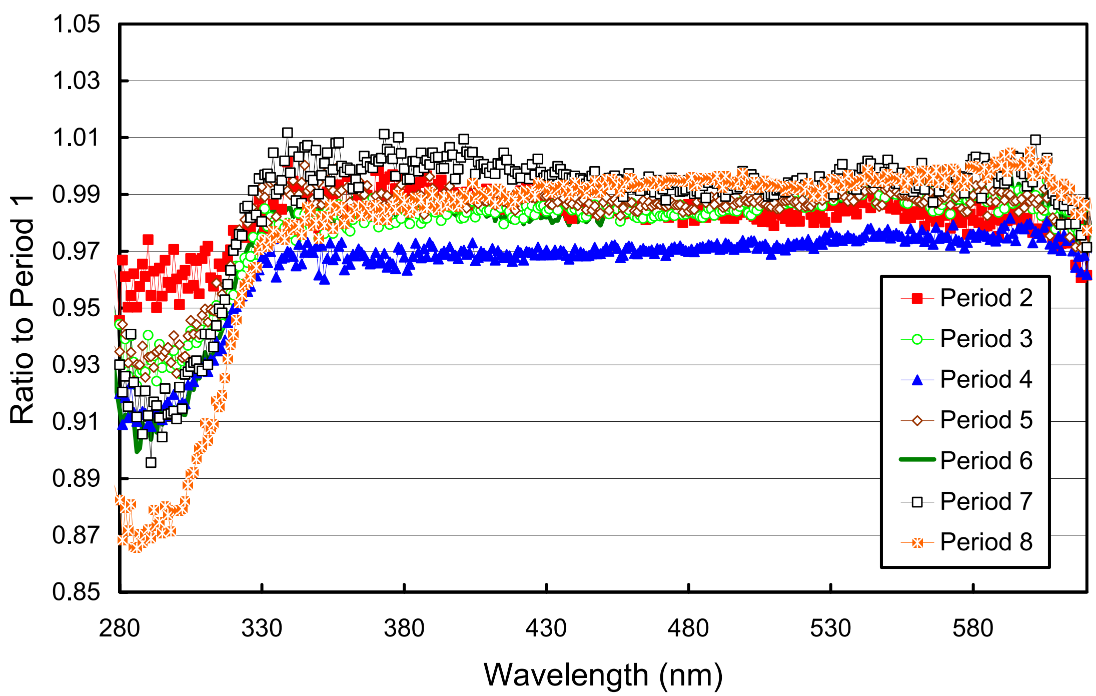

Figure 5.2.4. *Ratios of irradiances assigned to the internal reference lamp compared to Period 1.*

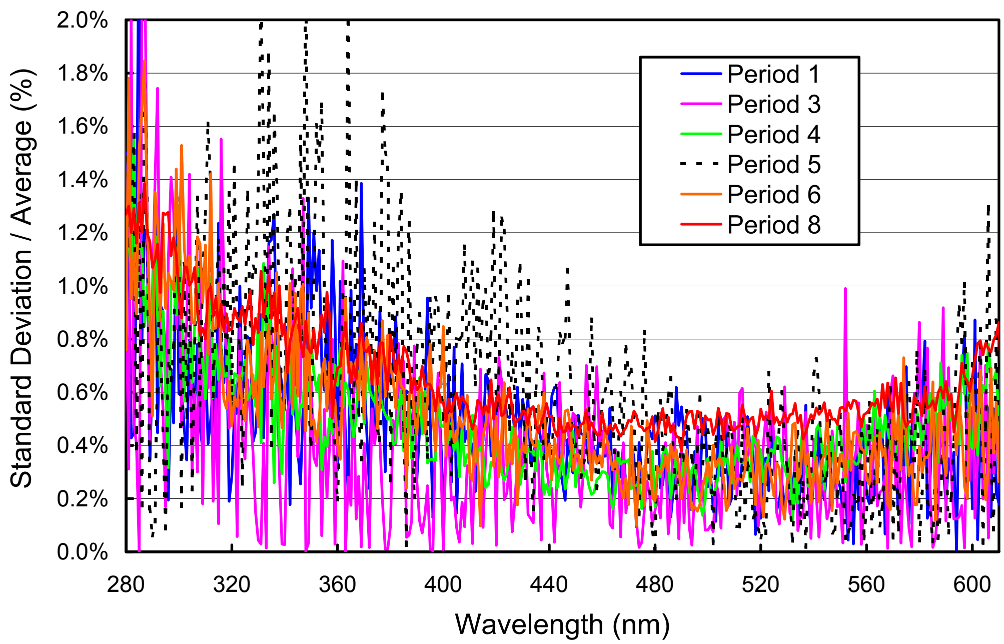

Figure 5.2.5. *Ratio of standard deviation and average calculated from the absolute calibration scans. The data for Periods 2 and 7 are not shown since they are based on one scan only.*

5.2.3. 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 5.2.6 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 433 scans were evaluated. For 92% of the days, the change in offset was smaller than ±0.025 nm; for 99% of the days the shift was smaller than ±0.055 nm. There was only one occasion when the offset-difference was larger than ±0.1 nm, caused by a power failure. Affected scans are not part of the published data set.

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.

Between the season start and September 2000, the wavelength-dependent bias was very stable, before it gradually changed by approximately 0.06 nm at longer wavelength. From January 2001 onward, the bias was again very stable. Because of these changes, two wavelength correction tables were implemented, with the change occurring on 11/1/00. Both correction functions are shown in Figure 5.2.7. In order to demonstrate the difference between the result of the Fraunhofer-correlation method and the method that was historically applied (see Section 4.2.2.1), Figure 5.2.7 also includes correction functions that were calculated with the “old” method, i.e., the functions are based on internal wavelength scans only.

After the data was wavelength corrected using the shift-function described above, the wavelength accuracy was tested again with the Fraunhofer method. The results are shown in Figure 5.2.8 for four UV wavelengths. The residual shifts are generally smaller than ±0.07 nm. There is more scatter at 310 nm during the austral winter because of the small solar irradiance levels that prevail during this part of the year. A shift in the pattern can be discerned on 11/1/00, when the correction tables change.

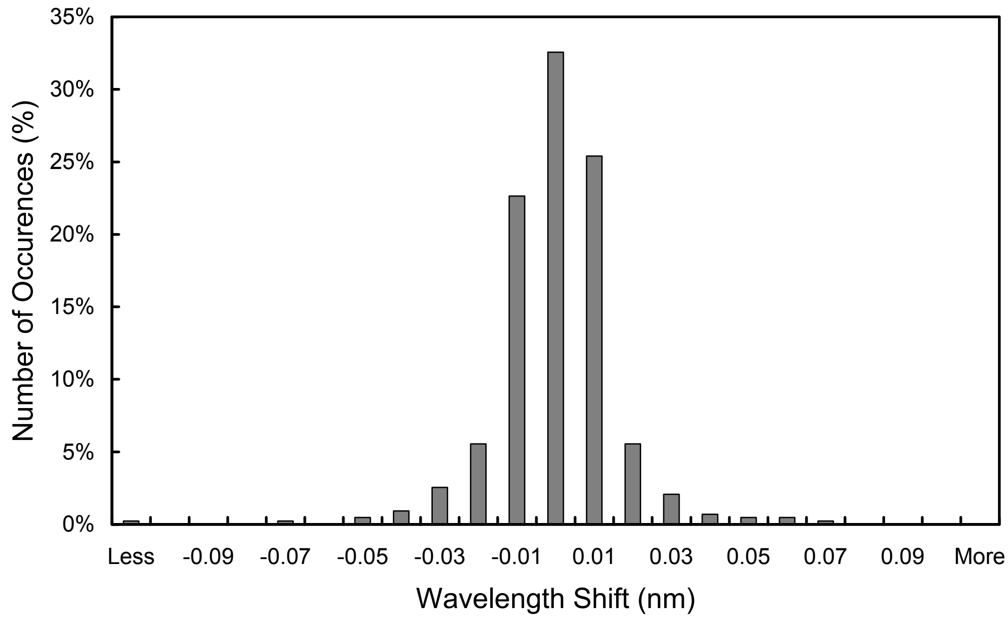

Figure 5.2.6. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. Thus the 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

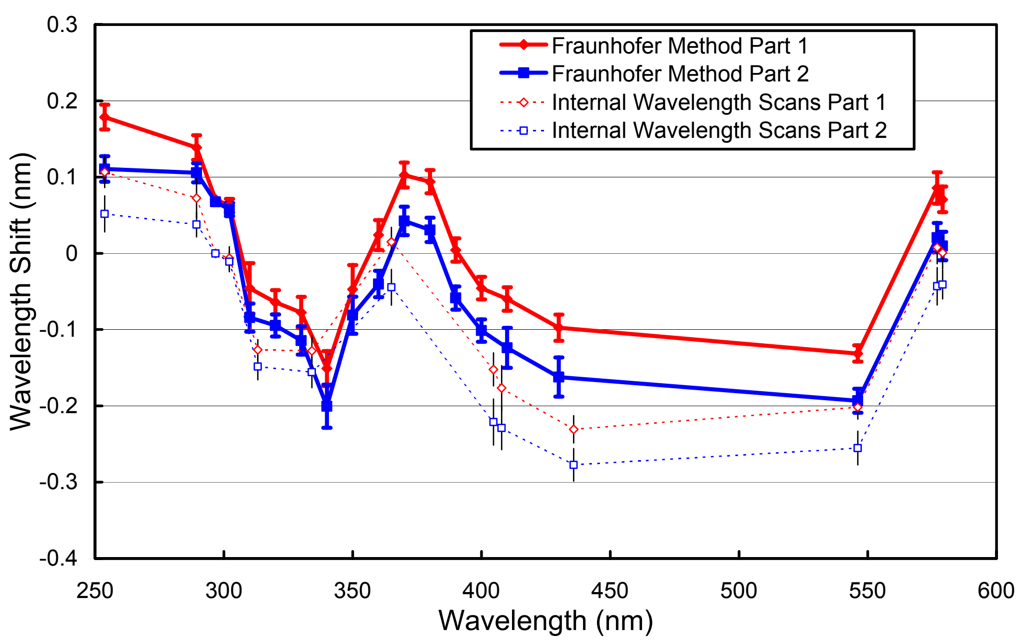

Figure 5.2.7. *Monochromator non-linearity for the Palmer 2000/01 season. Thick lines: Correction function calculated with the Fraunhofer-correlation method, and applied to correct the Palmer Volume 10 data. Part one includes the period 3/19/00 – 11/1/00; Part 2 the remainder of the season. Thin broken lines: Correction function calculated with the method that was historically applied. The error bars show the 1σ standard deviation of the wavelength shifts.*

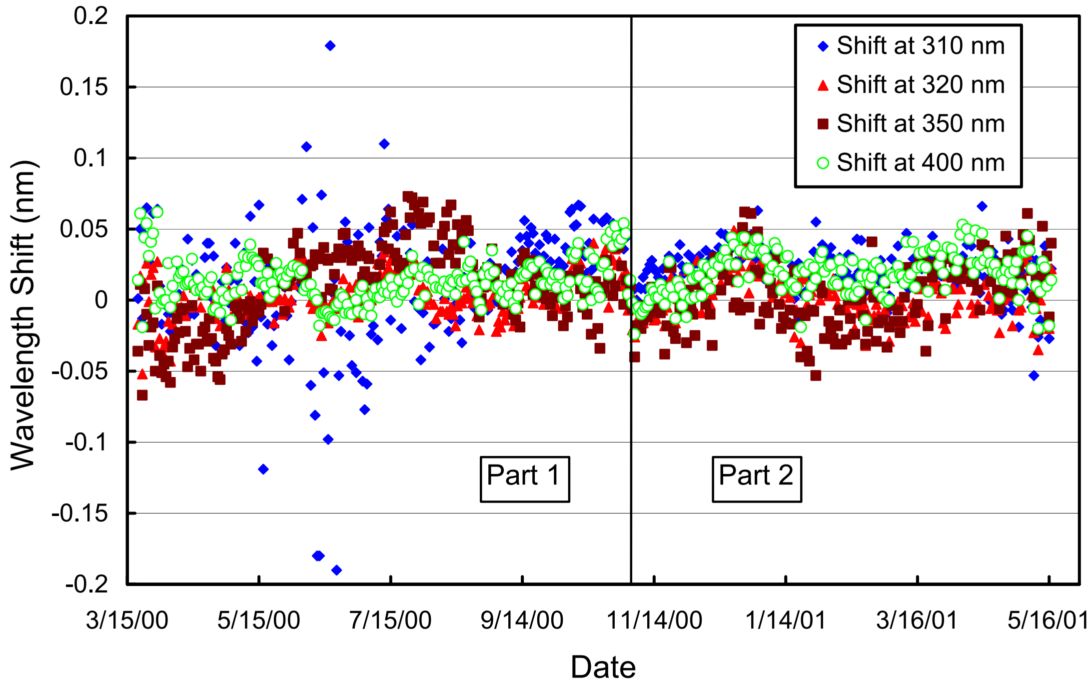

Figure 5.2.8. *Wavelength accuracy check of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season.*

Although data from the external mercury scans do not have a direct influence on the data products, they are an important part of instrument characterization. Figure 5.2.9 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. External scans have a bandwidth of about 0.95 nm FWHM, whereas the bandwidth of the internal scan is only 0.72 nm. Internal scans of both periods are shifted by about 0.07 nm to shorter wavelength with respect to their external counterparts. Since external scans have the same light path as solar measurements, they more realistically represent the monochromator bandpass relevant for solar scans.

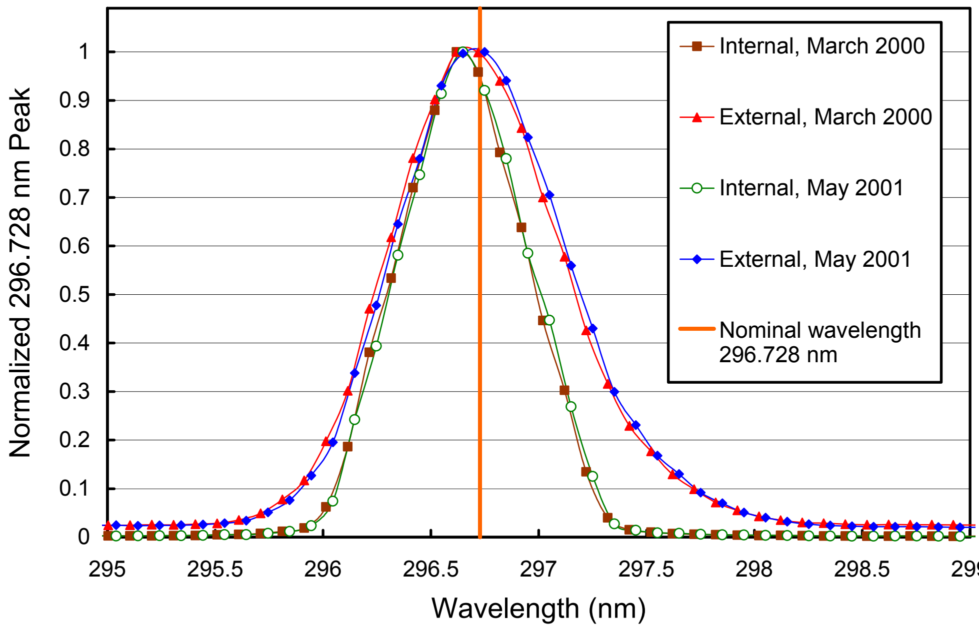

Figure 5.2.9. *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements.*

5.2.4. Missing Data

A total of 21596 scans are part of the published Palmer Volume 10 data set. These are 98% of all scans scheduled. Of the missing scans, 58, 54, and 112 were superseded by absolute, wavelength, and response scans, respectively. Since Palmer Station has almost 24 hours of sunlight per day in December, a loss of data scans cannot be avoided. Because of several power outages, which exceeded the capacity of the uninterruptible power supply, 70 scans were lost on 2/10/01 and 2/11/01. 48 scans were not recorded on 3/25/01 because of a full disk drive. For various other reasons, 18 additional scans were missed during different days throughout the season.