## 5.2. Palmer Station (4/6/98 – 5/2/99)

The 1998-99 season at Palmer Station is defined as the time between the site visits 3/26/98 – 4/5/98 and 5/3/99-5/18/99. The season opening and closing calibrations were performed on 4/2/98 and 5/4/99, respectively. Volume 8 solar data comprises the period 4/6/98 – 5/2/99. During this time, the system operated normally and the responsivity remained stable to within ±2%. About 99% of the scheduled data scans are part of the published dataset; less than 0.5% of all scans were lost because of technical problems.

### 5.2.1. Irradiance Calibration

The site irradiance standards for the 1998-99 Palmer season were the lamps 200W007, M-765, and M-700. As with all other sites, lamp M-874 was the traveling standard, which was used during season opening and closing calibrations. The lamp has two calibrations from Optronic Laboratories, one from August 1995 and one from September 1998. As mentioned in the introduction to Section 5, there are strong indications that the lamp has drifted by 2% between the beginning and middle of 1998. The analysis showed that the 1995 Optronic Laboratories calibration had to be applied for the Palmer Volume 8 opening calibrations. For the closing calibrations in 1999, the Optronic Laboratories calibration from 1998 was used, because M-874 appears to have been very stable from the second calibration date onward.

Lamp 200W007 was first introduced in the 1997/98 season and 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. Comparisons with M-874 and 200W007 indicate that lamp M-765 has drifted by about 1-2% over the years. In order to improve the accuracy of the data, lamp M-765 was recalibrated with M-874 using data from both lamps from day 5/11/99 (data from this day is part of the Volume 9 opening calibrations).

Lamp M-700 does not have a calibration from a standards laboratory. For use in the 1998-99 season, the lamp 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.

Figure 5.2.1 shows a comparison of all lamps at the end of the season (day 5/4/99). All lamps agree on the ±1% level. The good agreement of lamps M-700 and M-765 with M-874 can be expected since both lamps were calibrated with M-874 only a few days after performing the Volume 8 season closing calibrations. The validity of the calibration of M-874 is confirmed with the good agreement to lamp 200W007, which has an independent calibration.

At the beginning of the season (Figure 5.2.2), lamps M-874, 200W007, and M-700 agreed to within ±1% above 350 nm. At shorter wavelengths, there appears to be a systematic difference of 1.5-2% between all lamps and the traveling standard. There is also a difference of about 1% between M-765 and the other lamps at all wavelengths, indicating that M-765 has drifted over the season. This drift is one of the reasons why the lamp was recalibrated. In general, however, the agreement of all lamps is well within the typical uncertainties of irradiance standards calibrations, giving confidence in the solar data of the Palmer instrument of the 1998-99 season.

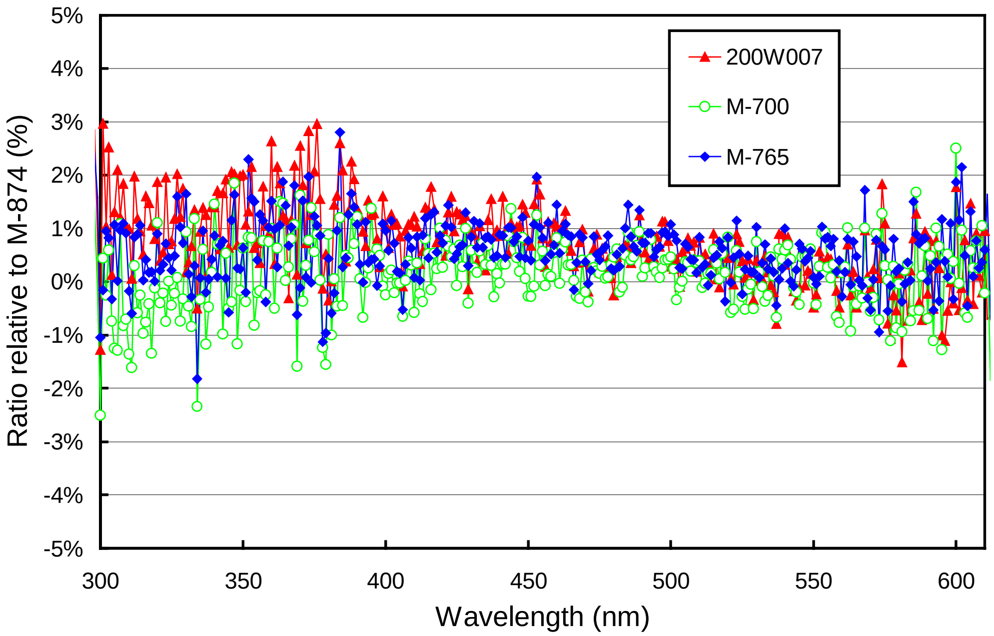


**Figure 5.2.1.** *Comparison of Palmer lamps 200W007, M-700, and M-765 with the BSI traveling standard M-874 at the end of the season (day 5/4/99).*

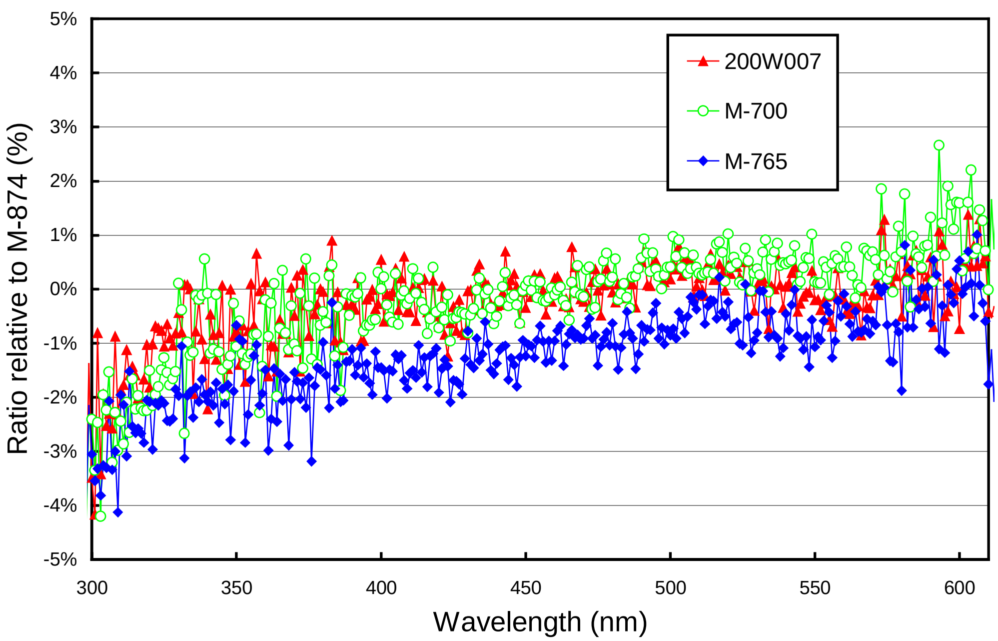


**Figure 5.2.2.** *Comparison of Palmer lamps 200W007, M-700, and M-765 with the BSI traveling standard M-874 at the beginning of the season (day 4/2/98).*

### 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. When TSI measurements indicate that the internal lamp has drifted by more than 2%, a new irradiance is assigned to this lamp, based on the bi-weekly absolute calibrations (see Section 4.2.1.2). 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 1998-99 season. The TSI measurements indicate that the internal lamp was very stable between the season start and September 1998. After September 1998 the brightness of the lamp gradually decreased. The lamp was about 3% dimmer at the end of the season compared with the start. On 3/16/99, the lamp output had decreased by 2% compared to the season start and the season was therefore split at this day into two periods, labeled Period 1 and Period 2 in Figure 5.2.3. Two separate calibrations of the internal lamp were established for each of the periods.

The PMT currents at 300 and 400 nm indicate that the instrument was stable to within ±2% during the entire season. The decrease in the currents between September 1998 and the end of the season tracks well the darkening of the internal lamp, suggesting that the system itself was very stable and the lower PMT currents reflect only the change of the lamp. Note that the change in instrument responsivity of about 2%, occurring in the first part of the season, does not affect solar data because the daily response scans are not only performed for monitoring drifts, but also for correcting these drifts.

The irradiance assigned to the internal lamp in Period 1 was calculated by analyzing 19 calibrations with the site irradiance standards carried out during this period. From each of these calibrations, irradiance values for the internal lamp were calculated and the mean-irradiance for this period was derived by averaging over the individual calibration functions, according to the procedure outlined in Section 4.2.1.2. The ratio of the standard deviation and average mean-irradiance, both calculated from the 19 calibrations, is a useful tool for estimating the variability of the calibrations for this period. As shown in Figure 5.2.4, the standard deviation is usually less than 1% of the average and increases slightly towards shorter wavelengths. Thus the calibrations during Period 1 are consistent to the ±1% (±1σ) level. The same procedure was also applied to Period 2, during which eight calibrations were preformed. The standard-deviation-to-average ratio for this period is also shown in Figure 5.2.4.

Figure 5.2.5 shows the ratio of the irradiance assigned to the internal lamp in Period 1 and Period 2. As can be seen, the irradiance in Period 2 is about 1-2% lower than the respective irradiance of Period 1. This change is consistent with the drift of the lamp as monitored by the TSI sensor.

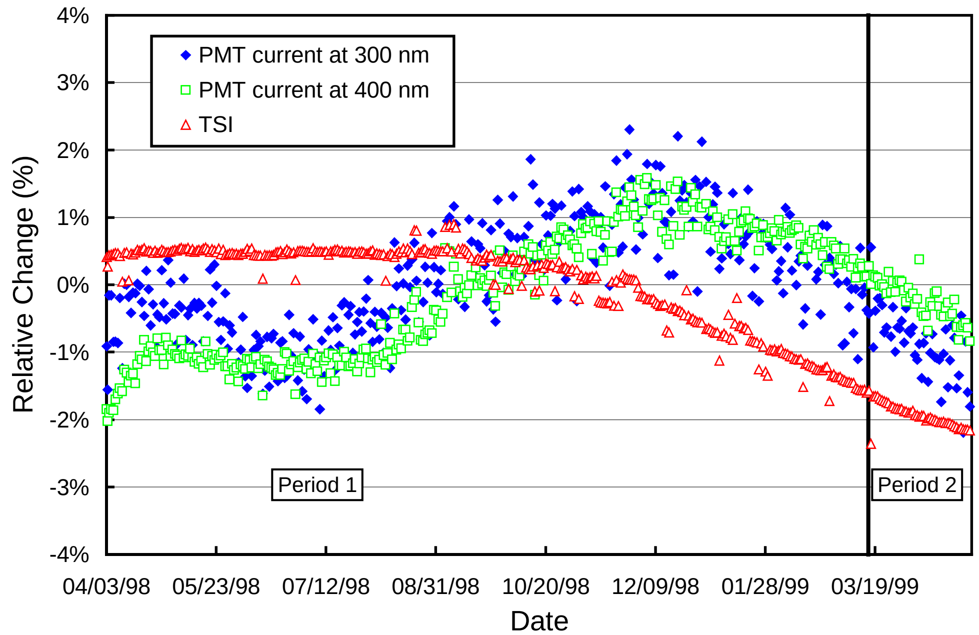


**Figure 5.2.3.** *Time-series of PMT current at 300 and 400 nm and TSI signal during measurements of the response lamp during the Palmer 1998-99 season. The data is normalized to the average of both periods.*

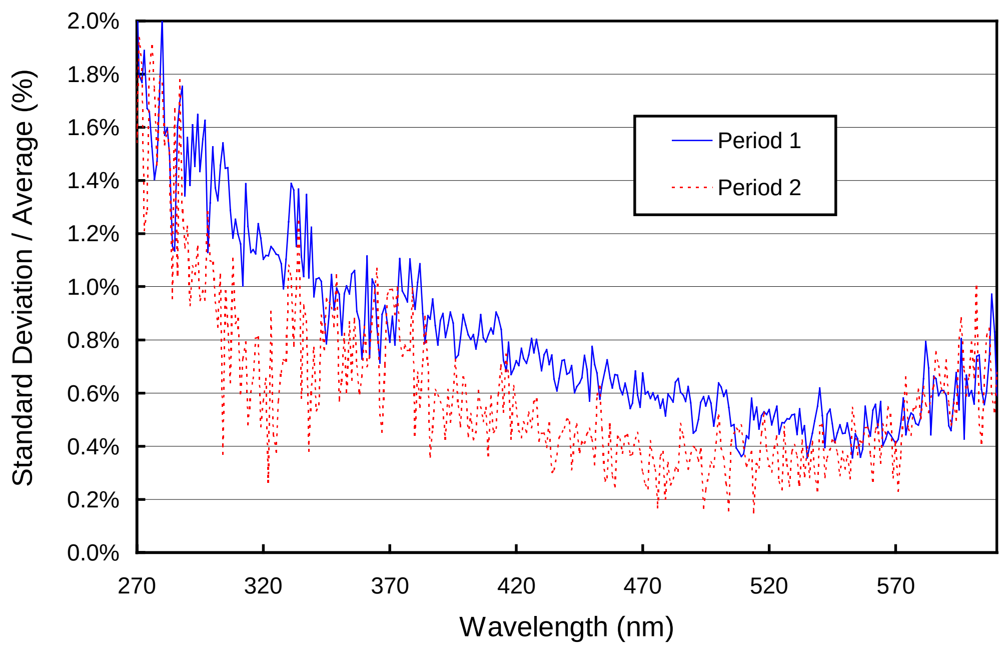


**Figure 5.2.4.** *Ratio of standard deviation and average calculated from the absolute calibration scans of Periods 1 and 2.*

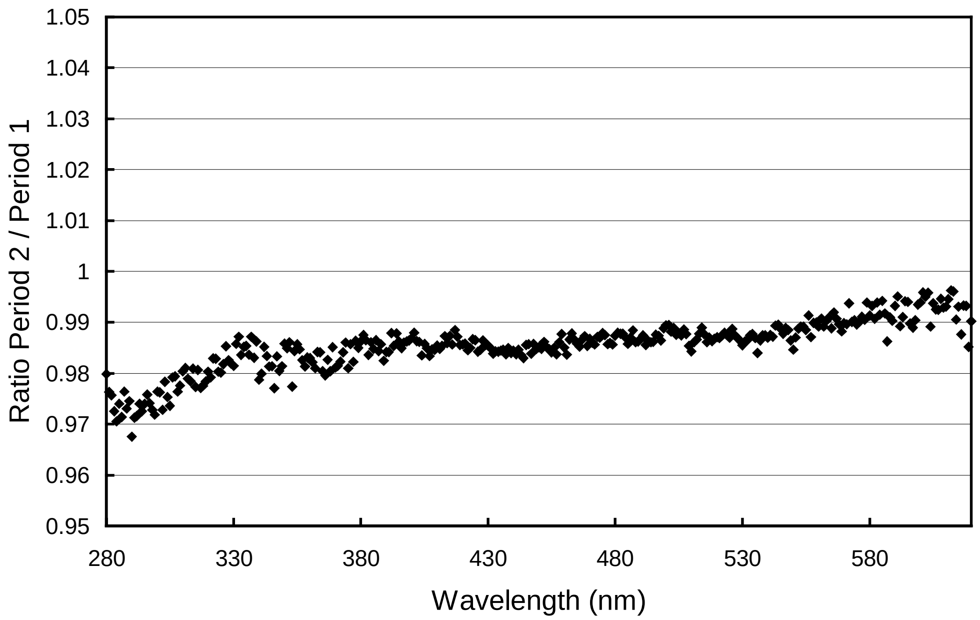


**Figure 5.2.5.** *Ratio of irradiance assigned to the internal reference lamp in Period 2 and Period 1.*

### 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, 388 scans were evaluated. For 88% of the days, the change in offset was smaller than ±0.025 nm; for 99.5% of the days the shift was smaller than ±0.075 nm. The offset-difference was only larger than ± 0.1 nm for two scans on 11/26/98, when the instrument did not correctly switch from automatic to manual mode upon operator intervention. The “pairing” of wavelength and data scans was adjusted appropriately.

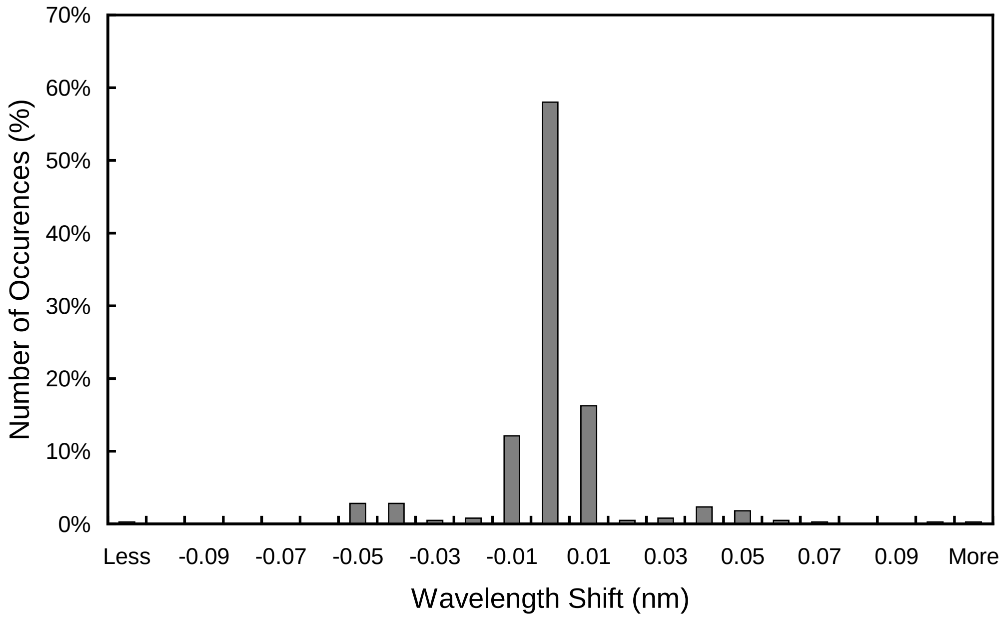


**Figure 5.2.6.** *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. Thus the 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more"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

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. The thick line in Figure 5.2.7 shows the resulting correction function that was applied to the Volume 8 Palmer data. The function clearly depends on wavelength, which is caused by non-linearities in the monochromator drive. In order to demonstrate the difference between the result of the Fraunhofer-correlation method and the method that was historically applied, Figure 5.2.7 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 0.12 nm. As explained in Section 4, 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 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 ±0.1 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. The actual wavelength uncertainty may be a little larger due to wavelength fluctuations of about ±0.02 nm during the day, and possible systematic errors of the Fraunhofer-correlation method (see Section 4.2.2.2).

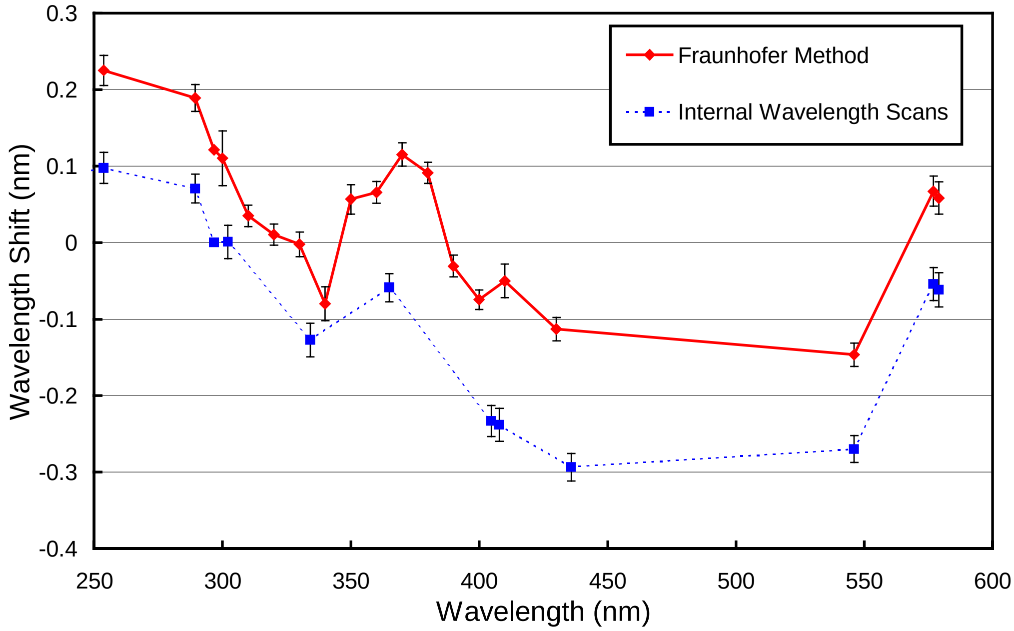


**Figure 5.2.7.** *Monochromator non-linearity for the Palmer 1998-99 season. Thick line: Correction function calculated with the Fraunhofer-correlation method, applied to correct the Palmer Volume 8 data. Thin broken line: Correction function calculated with the method that was historically applied. The offset difference between both methods is 0.12 nm. The error bars show the 1σ standard deviation of the wavelength shift for the season.*

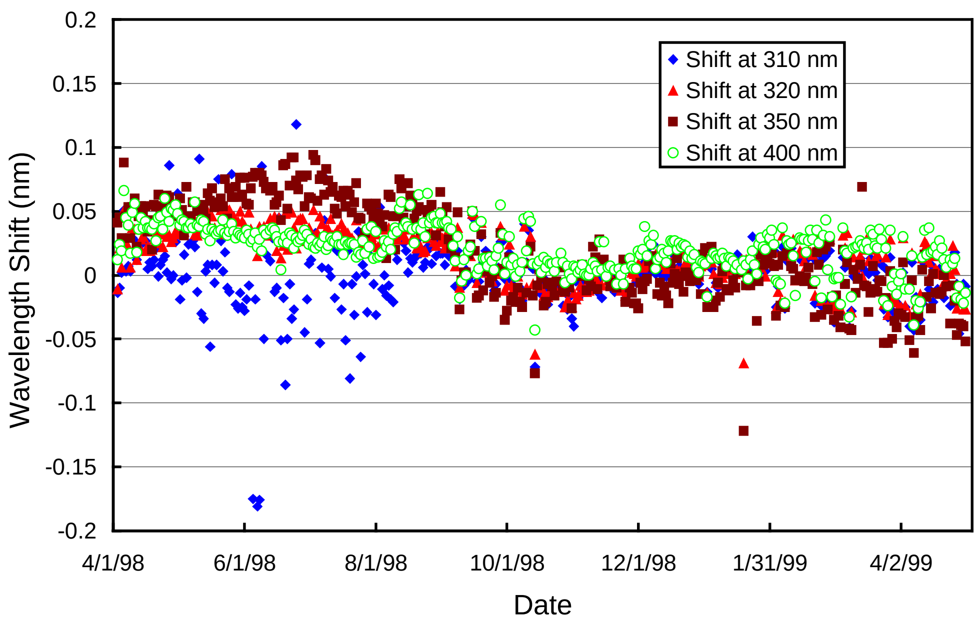


**Figure 5.2.8.** *Wavelength accuracy check of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season.*

Although data from the external mercury scans do not have a direct influence on the data products, they are, however, 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; the scale is based on a combination of the Fraunhofer-correlation technique and wavelength-offset determination with internal mercury scans. The peak of the external scans, which have the same light path as solar measurements, agrees well with the nominal wavelength of 296.73 nm, whereas the peak of the internal scans is shifted about 0.12 nm to shorter wavelengths. External scans have a bandwidth of about 1.0 nm FWHM, whereas the bandwidth of the internal scan is only 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 the start and end of the season are very consistent.

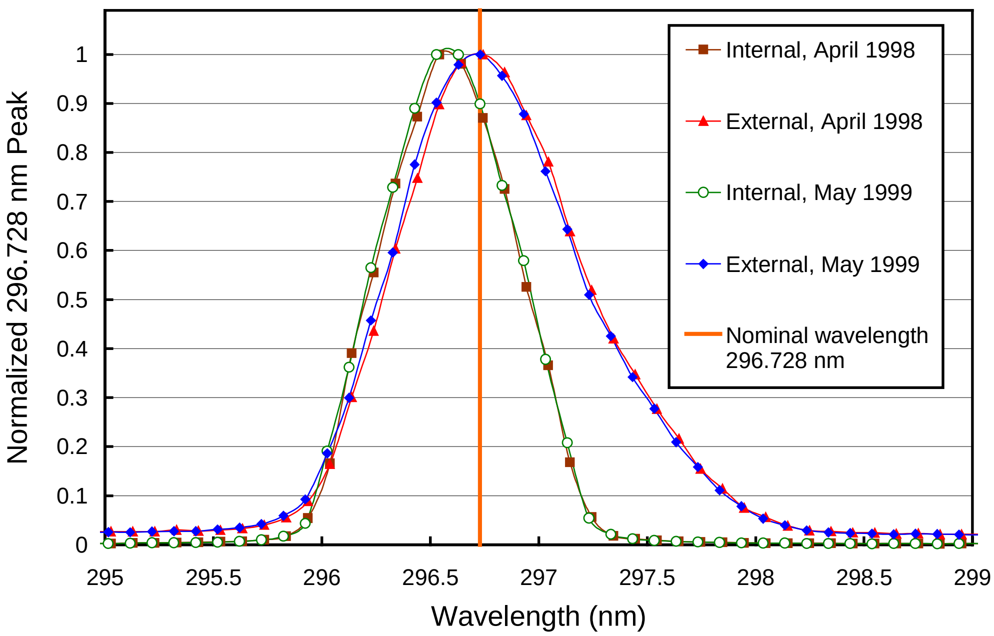


**Figure 5.2.9.** *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements, i.e., it is based on a combination of internal scans and the Fraunhofer-correlation method. It is assumed that the wavelength registration of the monochromator did not shift between internal and external scans, which were close in time.*

### 5.2.4. Missing Data

A total of 19881 scans with solar zenith angles smaller than 92° were scheduled to be measured in the Palmer Volume 8 season. Of these scans, 19657 (98.9%) were found to be of good quality and are therefore part of the published dataset. Of the missing scans, 49, 26, and 64 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. Approximately 47 scans were lost because of a full hard disk and 14 scans were lost for various other reasons. A total of 23 scans were aborted by the site operator and five scans were found to be defective. Both incomplete and defective scans were excluded from the dataset. A total of 20398 are listed in the published databases, including 741 scans with solar zenith angles between 92° and 95°.