5.1. McMurdo Station (2/6/00 – 1/22/01)

The 2000/01 season at McMurdo Station is defined as the time between the site visits 1/30/00-2/6/00 and 1/22/01-1/27/01. The season opening and closing calibrations were performed on 2/6/00 and 1/22/01, respectively. Volume 10 solar data comprises the period 2/6/00 – 1/22/01. The system operated normally during this time and the system responsivity remained stable to within ±4%. This uncertainty was further reduced using the daily scans of the internal lamp.

The collector of the instrument was modified during the site visit in 2000. This upgrade resulted in substantially decreased azimuth errors, which affected solar data of previous volumes (see the introduction to Chapter 5). During the site visit in 2001, 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 compensated for the reduction in sensitivity due to the collector upgrade. Data analysis revealed that solar noon-time irradiance measurements in the visible were higher by several percent in years prior to the collector upgraded compared to Volume 10 data. The modification therefore introduced a step-change in the time series of measurements in the visible. UV irradiances and daily doses are less affected. The change is discussed in more detail in the introduction of Chapter 5. About 96% of the scheduled data scans are part of the published dataset; less than 1% of all scans were lost because of technical problems.

The PSP and TUVR instruments installed at McMurdo were replaced by identical instruments during the site visit in January 2001. The PSP that was installed during the Volume 10 period has identical Eppley Laboratory calibrations from 11/8/00 and 2/21/01. The TUVR calibrations are from 11/11/99 and 2/21/01 and deviate by more than 40%. Analysis of the data revealed that the instrument itself was stable and that the difference must be a calibration error by Eppley Laboratory. The scale factor applied to solar data was chosen such that TUVR values from the Volume 10 period matched those from Volume 9 in magnitude. Because of this somewhat arbitrary calibration, TUVR data have to be treated with caution.

5.1.1. Irradiance Calibration

The site irradiance standards for the 2000/01 McMurdo season were the lamps 200W005, 200W019, and M-543. Lamps M-874 and M-764 were used as traveling standards. Lamps 200W005 and 200W019 have Optronic Laboratories certificates from November 1996 and September 1998, respectively. Lamp M-543 was calibrated by comparison with M-874 using data centered around the 1999 site visit using the procedure outlined in Section 4.2.1.5. The calibrations of 200W005, 200W019 and M-543 were the same as used during the Volume 9 season. The traveling standard M-874 became unstable during the second half of 2000 and was therefore used only during the season opening. M-764 was originally calibrated by Optronic Laboratories in 1992 and recalibrated in March 2001, shortly after the season closing calibrations at McMurdo.

Figure 5.1.1 shows the Volume 10 season opening calibrations performed on 2/6/00. All site standards agree on the ±1.5% level with a slightly larger difference around 320 nm. There is a wavelength-dependent bias compared to the measurement with the traveling standard M-874. This bias is most likely due to M-874, which was drifting during 2000, as mentioned above.

Figure 5.1.2 shows a similar comparison of the three site standards at the end of the season. The measurements are referenced to M-764 using the Optronic Laboratories calibration from March 2001 for this lamp. All site standards agree on the 0.5% level, but there is a 1% bias compared to M-764. If the 1992 calibrations of M-764 had been used, this bias would disappear. A difference in the order of 1% is still within the uncertainty of irradiance standard calibrations.

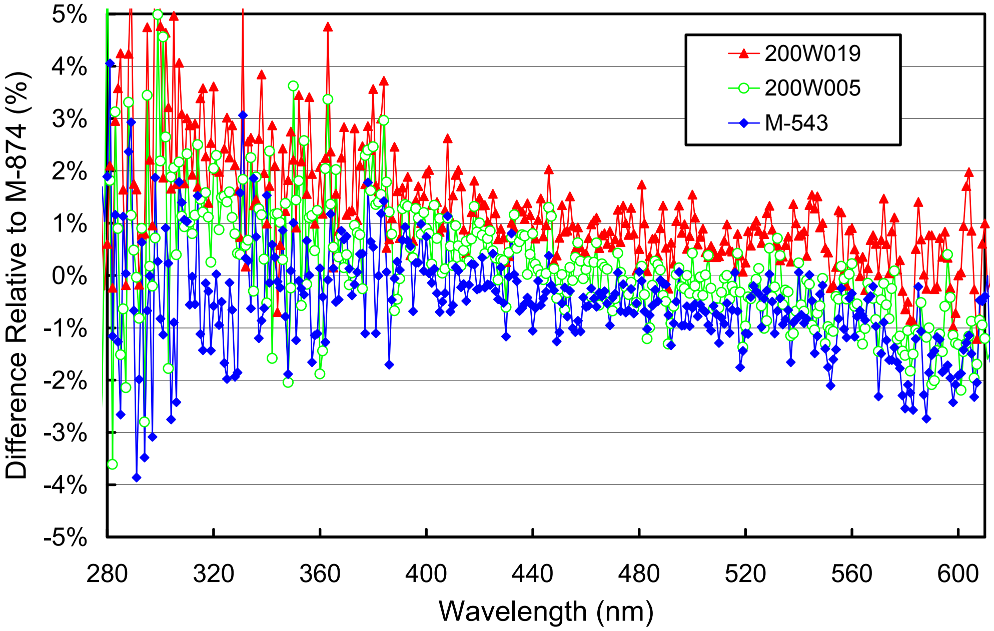

Figure 5.1.1. *Comparison of McMurdo lamps 200W005, 200W019, and M-543 with the BSI traveling standard M-874 at the beginning of the season (2/6/00).*

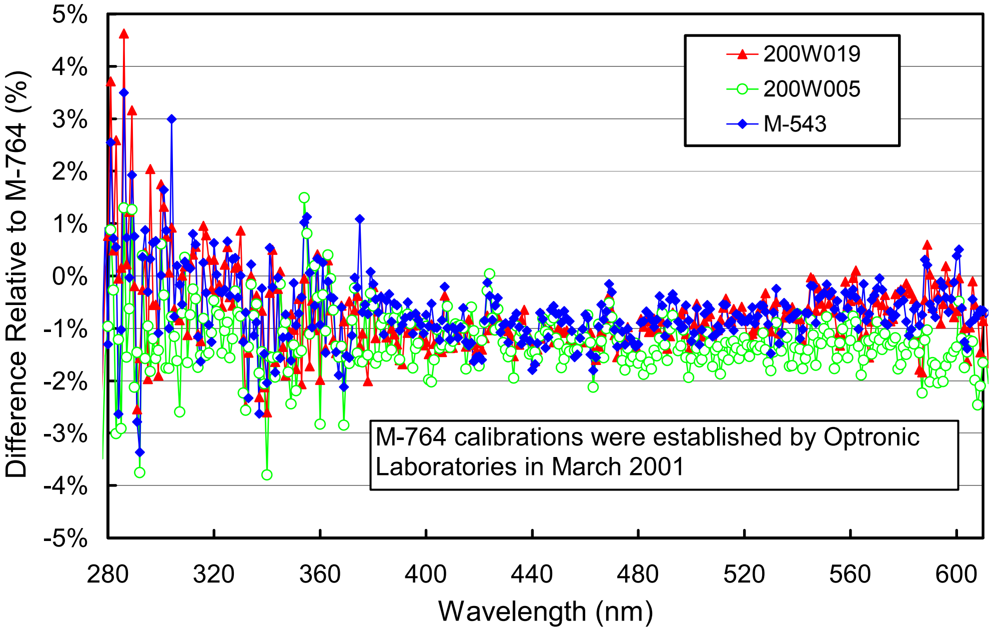

Figure 5.1.2 *Comparison of McMurdo lamps 200W005, 200W019, and M-543 with the BSI traveling standard M-764 at the end of the season (1/22/01).*

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 2000/01 season. TSI measurements fluctuated by less than ±1.5% during the entire season, indicating stability of the internal lamp. PMT currents decreased by 4% during the first several months, and increased thereafter to reach about the same level at the end of the season than at the beginning. Note that this annual cycle has also been observed during previous seasons. It's actual reason is unknown. 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%.

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 three periods, denoted Periods 1 – 3. The irradiance assigned to the internal lamp was calculated separately for each period following the procedure described in Section 4.2.1.2. Period 1 includes all measurements before the polar night. Figure 5.1.4 shows that the instrument's responsivity changed only very little during the months of darkness. The change between Period 2 and 3 is about 2%. Figure 5.1.5 presents the ratio of the standard deviation and average of the spectra used for each period. These ratios are useful for estimating the variability of the calibrations in a given period. As can be seen, the variability in all periods is very similar; the standard deviation is usually less than 1% of the average, except below 320 nm, where it rises to 2%.

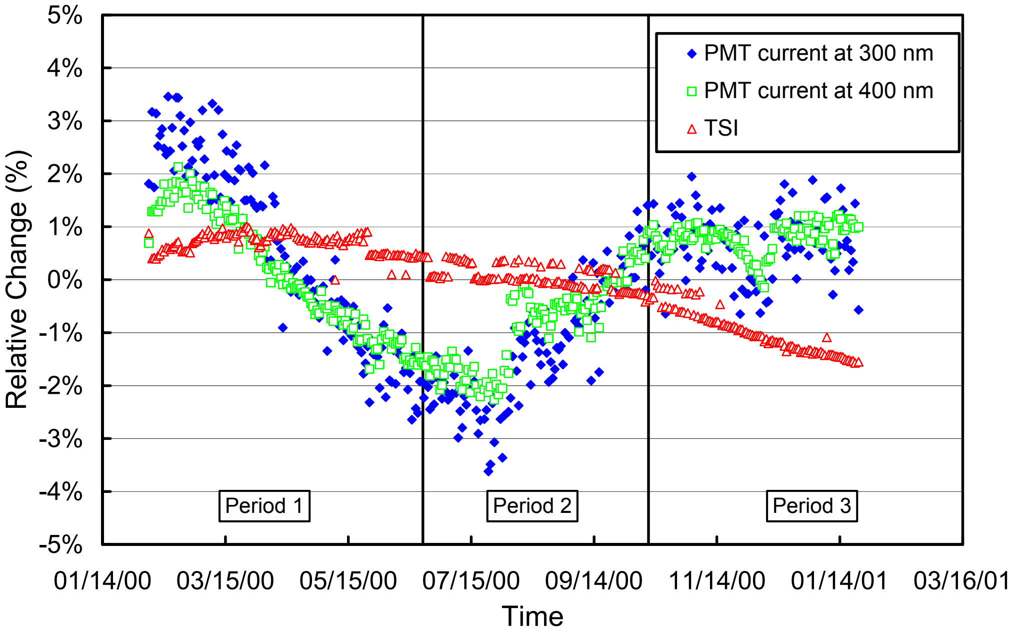

Figure 5.1.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal during measurements of the internal irradiance reference lamp during the McMurdo 2000/01 season. The data is normalized to the average value of the whole season.*

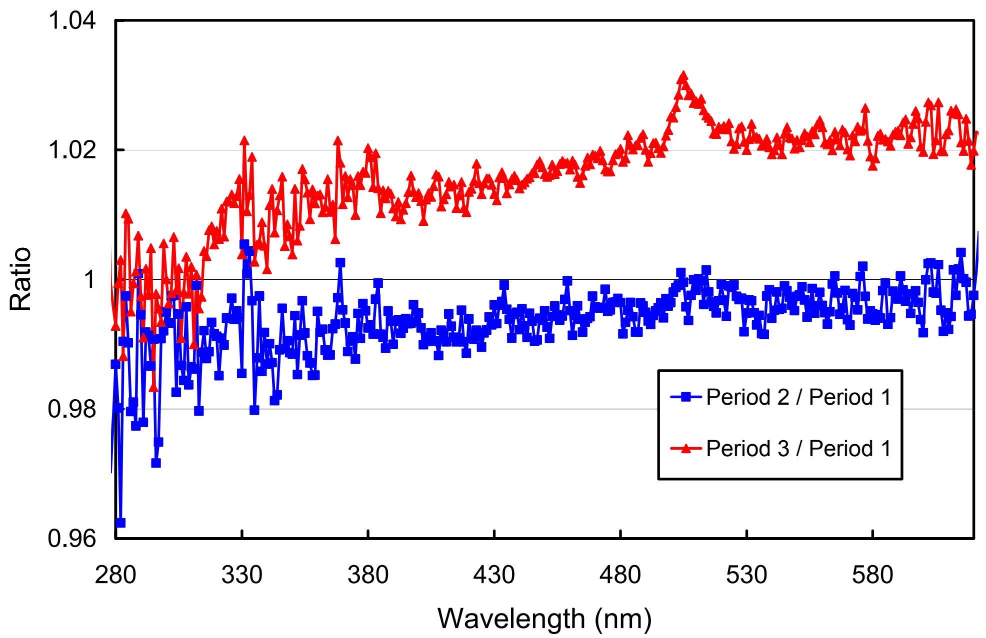

Figure 5.1.4 *Ratio of irradiance assigned to the internal reference lamp.*

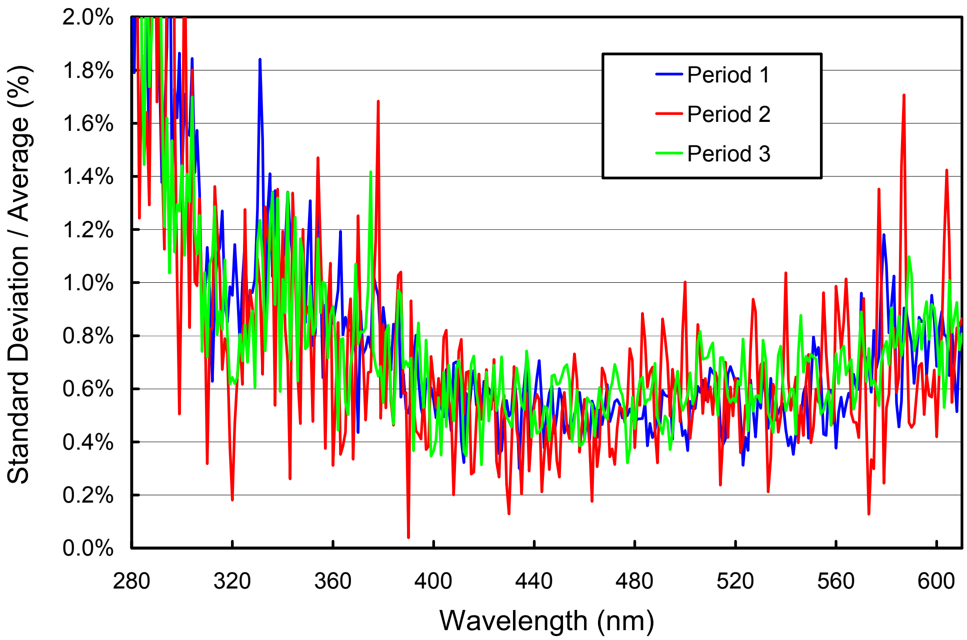

Figure 5.1.5. *Ratio of standard deviation and average calculated from the absolute calibration scans measured during the McMurdo 2000/01 season.*

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 pairs of scans have been evaluated. For 82% of the days, the offset change is smaller than ±0.025 nm; for 99% of the days the shift is smaller than ±0.055 nm. The offset-difference is larger than ± 0.1 nm for 1 scan only, and the wavelength calibration was adjusted appropriately.

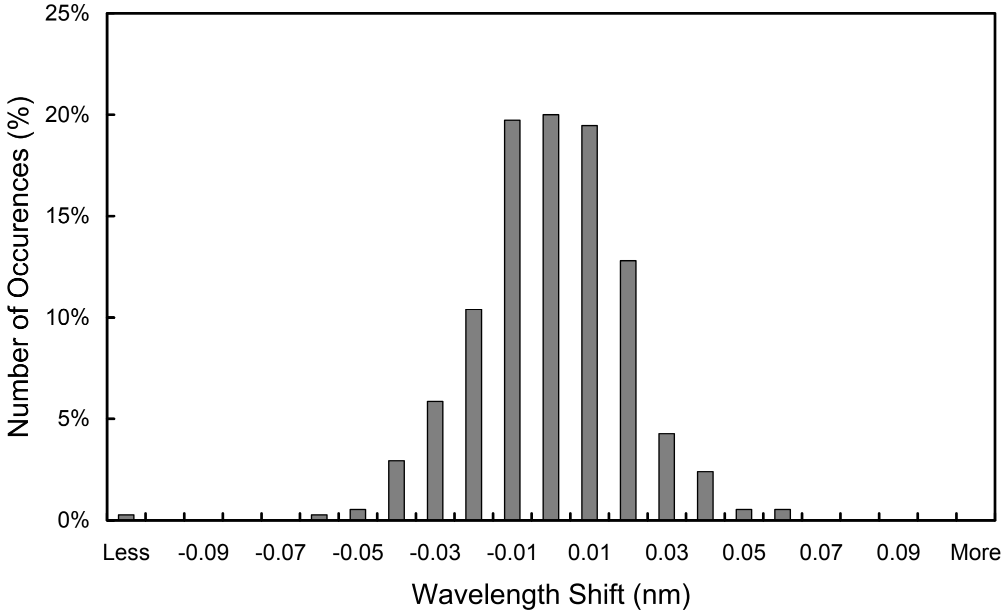

Figure 5.1.6. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means 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. The correction function is shown in Figure 5.1.7. 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 ±0.05 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.

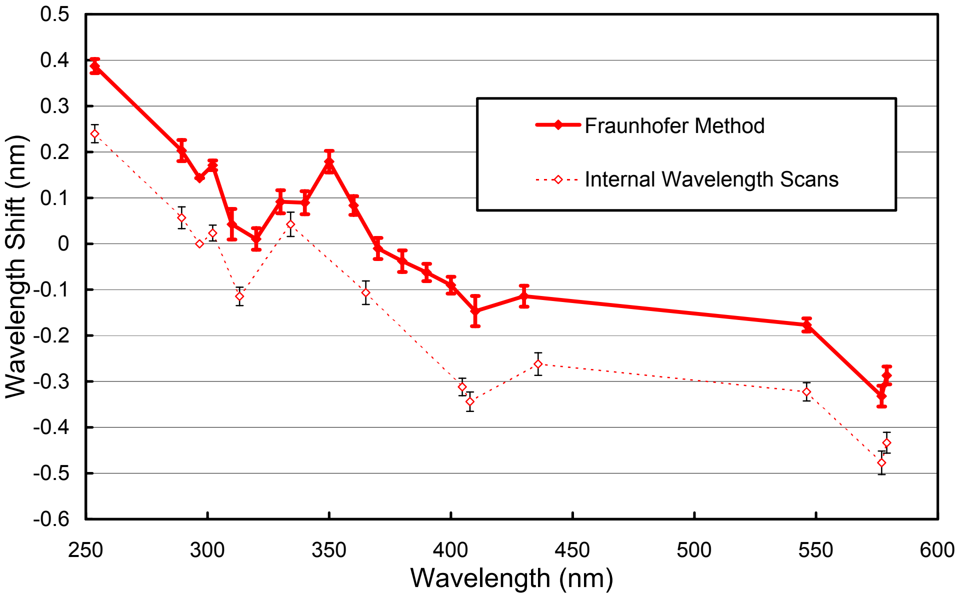

Figure 5.1.7. *Monochromator non-linearity for the McMurdo 2000/01 season. Line: Correction functions calculated with the Fraunhofer-correlation method. Broken line: Correction function calculated with the method that was historically applied. The offset difference between both methods is 0.14 nm. The error bars show the 1σ standard deviation of the wavelength shift.*

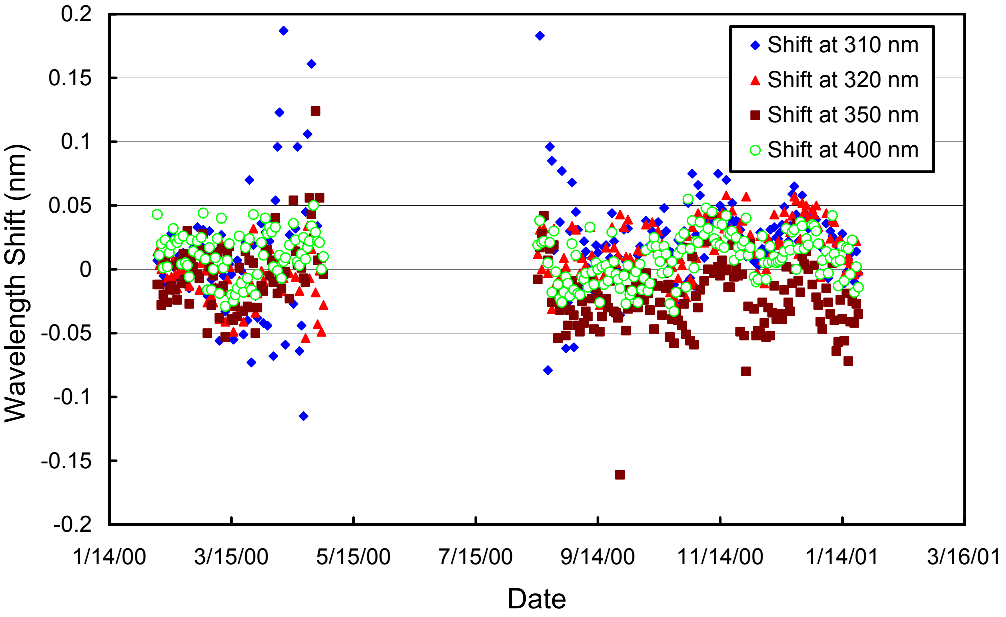

Figure 5.1.8. *Check of the wavelength accuracy of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season. No correlation data is available during the polar night.*

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 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.

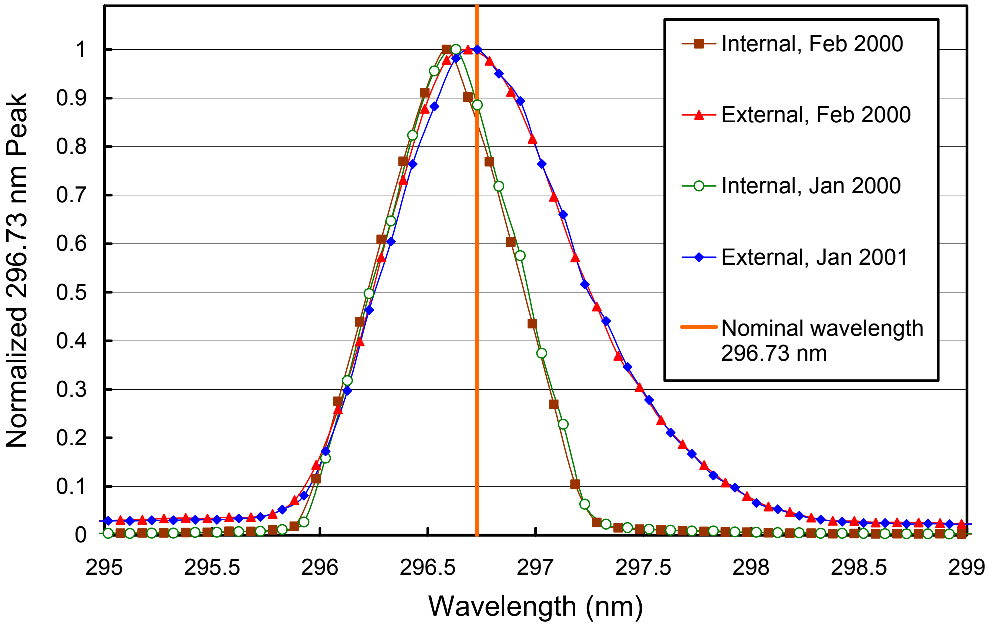

Figure 5.1.9 *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements, i.e., it is based on a combination of internal scans and the Fraunhofer-correlation method. It is assumed that the wavelength registration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

5.1.4. Missing Data

A total of 16803 scans are part of the published McMurdo Volume 10 dataset. These are 96% of the scans scheduled. Less than 1% of all scans were missed due to technical problems. Of all missing scans, 60, 138, and 234 were superseded by absolute, wavelength, and response scans, respectively. On 9/25/00 and 9/26/00, 61 scans were lost due to a power outage. Immediately after a response scan on 10/25/00, 13 data scans were found to be defective and excluded from the published data set. Probably due to a problem with the software's scan scheduler, no scans were recorded on 11/5/00 until 12:30 GMT, causing a loss of 51 scans.