## 5.3. Amundsen-Scott South Pole Station (1/20/01–1/13/02)

The 2001-2002 season at Amundsen-Scott South Pole Station is defined as the period between the site visits 1/12/01-1/19/01 and 1/12/02 - 1/18/02. The season opening and closing calibrations were performed on 1/18/01 and 1/13/02, respectively. Volume 11 solar data comprise the period 1/20/01–1/13/02. More than 92% of the scheduled scans are part of the data set; 4.5% are missing because of technical problems. Except of the issues described in the following, the system performed well:

- **Ice build-up underneath the collector**
  Between 10/01/00 and 10/27/01, moisture was freezing underneath the collector and changed the throughput by about 1% in the visible and 3-5% in the UV. The change in responsivity was corrected by adjusting the system's calibration during the period affected. A similar problem occurred in November and December 2000. We believe that the problem is caused by the modification of the instrument's collector during the site visit in January 2000. The upgrade involved installing a field-of-view limiting aperture underneath the cosine diffuser. This significantly improved the instrument's angular response but may have decreased the heat flow from the roof box to the collector. We therefore replaced the aperture that was made of PTFE with one made of aluminum (which has a better thermal conductivity than PTFE) during the 2002 site visit.
- **Drift of internal lamp**
  The internal lamp gradually became brighter by 12% during the season The magnitude of the drift significantly exceeded typical changes for this lamp type. As the drift was a smooth function of time it could be corrected by adjusting the instrument's calibration accordingly. The additional uncertainty in published solar data is therefore small.
- **Monochromator misalignment**
  It was discovered during the site visit in 2001 that the drive mechanics of the previously installed monochromator were sticky. The monochromator was therefore returned for refurbishment and the site spare monochromator was installed. Unfortunately the monochromator was found to be not well aligned, which caused a lower throughput and larger wavelength non-linearity than typical. In addition, its slit function had a comparatively broad foot (see Section 5.3.3). The effect on published solar measurements is small: the detection limit was not discernibly altered by the reduced throughput, and the enhanced wavelength non-linearity could be corrected. The effect of the band shape distortion was calculated and was found to increase erythemal irradiance values by less than 0.2%. The monochromator was realigned and reinstalled during the site visit in 2002.
- **Difference in measurements in the visible between Volume 11 and Volume 10**
  Volume 11 spectral irradiance data in the visible (400 – 600 nm) appears to be 1-4% lower than Volume 10 data. Both datasets were double-checked, yet the reason of this difference could not be identified. It is likely a combination of various causes such as drifts of calibration lamps and a different acceptance angle of the two monochromators used during the Volume 10 and 11 seasons. UV data of both season were found to be consistent. See Section 7.3 for more information.
- **Computer problems**
  A new system control computer was installed during the site visit in 2001. The new computer locked up several times, and the old computer was therefore reinstalled on 3/28/01. This solved the problems. The cause of the lock-ups could be traced back to the driver of a serial port card, which is used to control external system components. A similar problem was noticed at Barrow when the computer there was upgraded. The driver of the new computer at the South Pole was changed during the site visit in 2002, and the computer was thoroughly tested. Because of the computer lock-ups, 590 data scans were lost in February and March 2001. See Section 5.3.4 for a listing of days affected.

The PSP and TUVR instruments installed at South Pole were replaced by identical instruments during the site visit in January 2002. The PSP that was installed during the Volume 11 period was calibrated by Eppley Laboratory Inc. in August 2000 and February 2002. The two calibration were in agreement to within 0.1%. Published data are based on the calibration from August 2000. The TUVR was calibrated by Eppley Laboratory Inc. in October 2000 and February 2002. Both calibrations agreed to within 2.3%. The calibration from October 2000 was implemented.

### 5.3.1. Irradiance Calibration

The site irradiance standards for the 2001/02 South Pole season were the lamps 200W006, 200W021, and M-666. Lamp M-764 was used as the traveling standard at the beginning and end of the season. The lamp was re-calibrated by Optronic Laboratories in March 2001.

Lamps 200W006 and 200W021 have irradiance calibrations of Optronic Laboratories from November 1996 and September 1998, respectively. Lamp M-666 was calibrated with lamps 200W006 and 200W021 using season closing scans of Volume 9 and opening scans of Volume 10. See Section 4.2.1.5. for further explanations on the method of transfer. For Volume 11, the same calibration functions were used as for Volume 10.

Figure 5.3.1 shows a comparison of 200W006, 200W021, and M-666 with M-764 the start of the season (1/18/01). The figure indicates that all site standards agree with each other to within ±1%. The deviation to the traveling standard M-764 is about –1 to -1.5% in the UVA and visible and 0 to 1.5% in the UVB. Figure 5.3.2 shows a similar comparison of the site standards at the end of season. There is virtually no bias between the site standards 200W021and M-666 and the traveling standard M-764. The 2% difference between lamps 200W006 and M-764 is still within the uncertainty of lamp certificates.

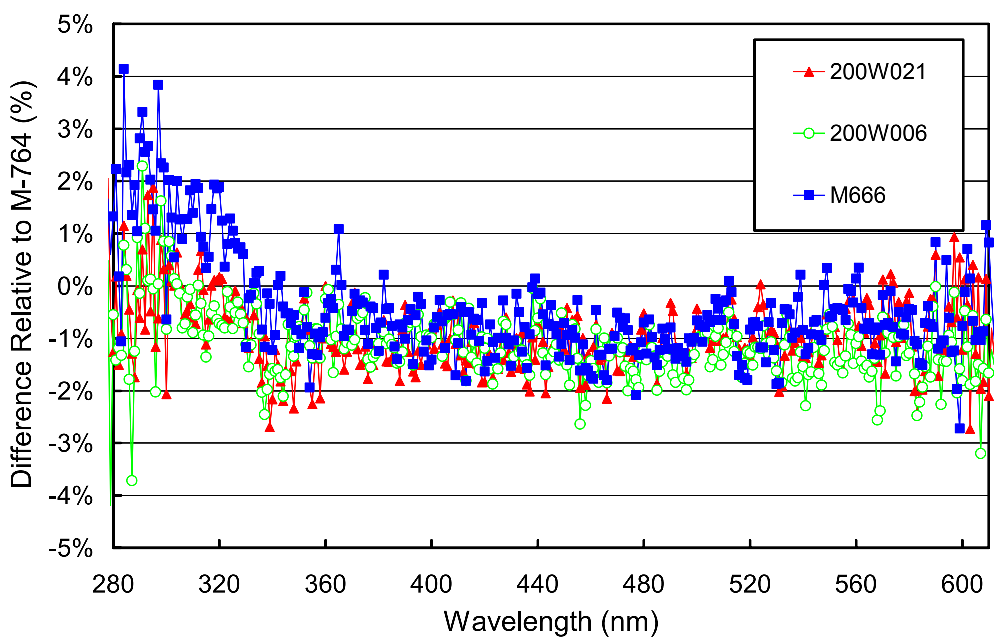


**Figure 5.3.1.** *Comparison of South Pole lamps 200W006, 200W021, and M-666 with the BSI traveling standard M-764 at the start of the season on 1/18/01.*

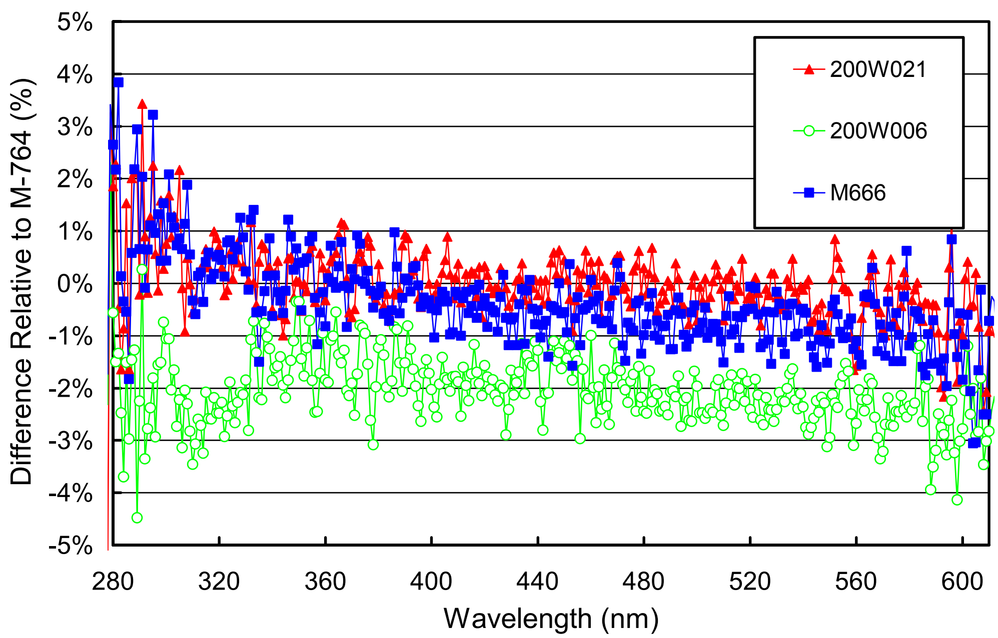


**Figure 5.3.2.** *Comparison of South Pole lamps 200W006, 200W021,M-666 with the BSI traveling standard M-764 at the end of the season on 1/13/02.*

## 5.3.2. Instrument Stability

The stability of the spectroradiometer over time is primarily monitored with bi-weekly calibrations utilizing site irradiance standards, and daily response scans of the internal irradiance reference. The stability of the internal lamp is monitored with the TSI sensor, which is independent from possible monochromator and PMT drifts.

Figure 5.3.3 shows the changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily response scans of the South Pole 2001/02 season. The TSI measurements show that the internal lamp became brighter by about 13% during the year. The PMT currents at 300 and 400 nm are well tracking the signal of the TSI, suggesting that monochromator and PMT were stable to within ±1% during the entire season. This increase of the internal lamp's flux is much larger than typical, but could be corrected by frequent changes of the instrument's calibration.

Changes in the fore-optics cannot be detected with response scans. As mentioned above, ice was building up underneath the collector in October until the collector was cleaned on 10/28/01. This caused the instrument responsivity to decrease by about 2% in the visible and 6% in the UV-B. The calibration was adjusted accordingly.

Because of the drift of the internal lamp and the change in system responsivity due to the ice build-up, 10 different calibration functions were used for Volume 11. Table 5.3.1 gives an overview of the 10 periods, and Figure 5.3.4 shows the ratios of the calibration functions relative to the function applied in Period P1. The difference between two consecutive calibration functions is typically smaller than 2%. The gap of 3% between P2 and P3 is irrelevant because these two periods are separated by the Polar Night. Note that the calibration functions for P3 (before ice build-up) and P3D (immediately after removal of the ice) are almost identical.

**Table 5.3.1 Calibration periods South Pole Volume 11.**

| Period name | Period range |
|---|---|
| P1 | 01/18/01 - 02/11/01 |
| P2 | 02/12/01 - 06/30/01 |
| P3 | 07/01/01 - 09/30/01 |
| P3B | 10/01/01 - 10/15/01 |
| P3C | 10/16/01 - 10/27/01 |
| P3D | 10/28/01 - 11/11/01 |
| P3E | 11/12/01 - 11/26/01 |
| P4 | 11/27/01 - 12/7/01 |
| P4B | 12/08/01 - 12/23/01 |
| P5 | 12/24/01 - 01/15/02 |

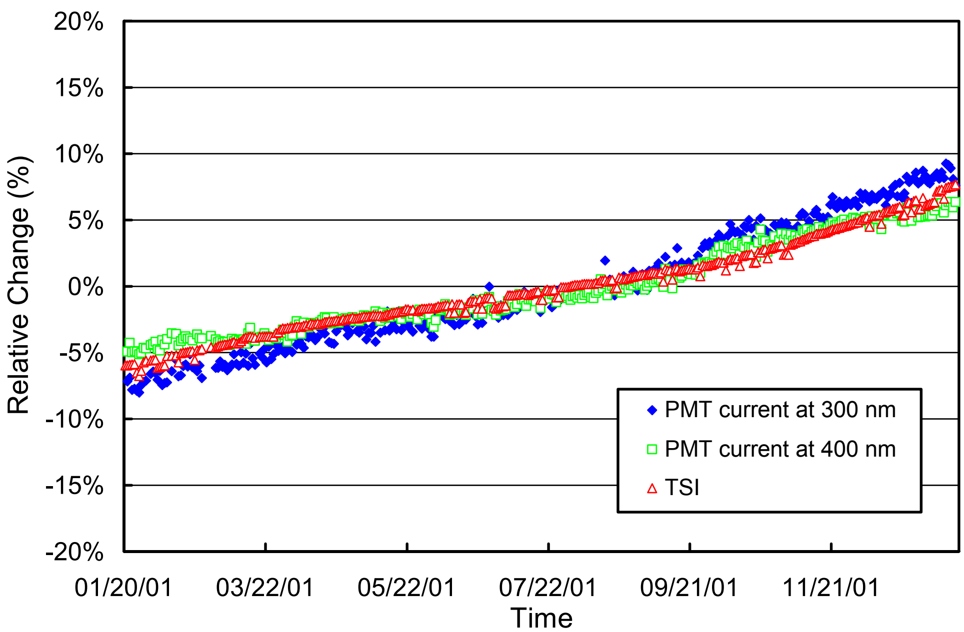


**Figure 5.3.3.** *Time-series of PMT current at 300 and 400 nm, and TSI signal during measurements of the internal irradiance standard performed during the South Pole 2001/02 season. The data are normalized to the average of the whole period.*

Figure 5.3.5 presents the ratios of the standard deviations 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 is typically less than 1.5% for wavelengths above 300 nm in all periods.

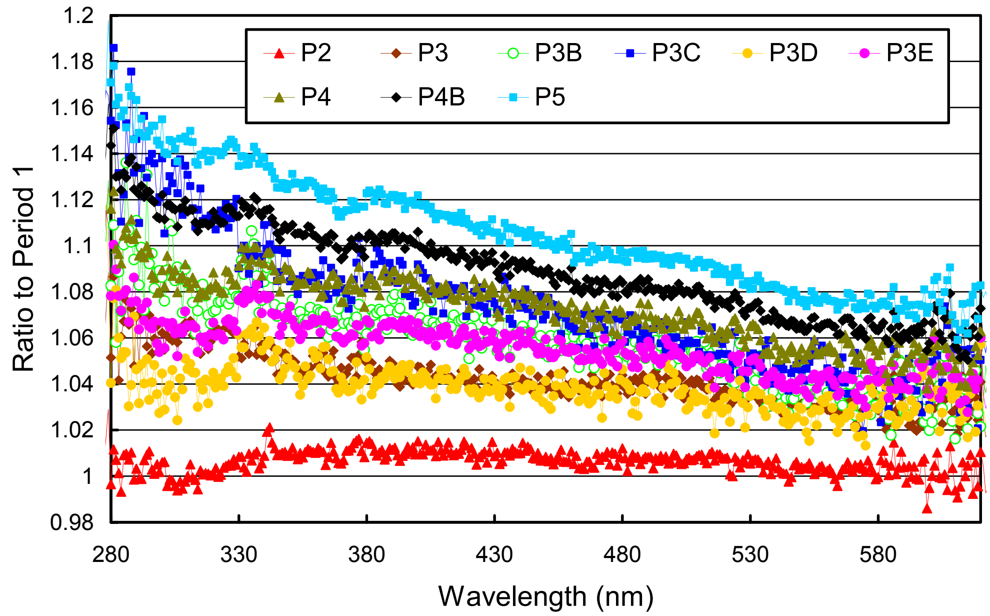


**Figure 5.3.4.** *Ratios of the irradiance assigned to the internal lamp relative to Period 1.*

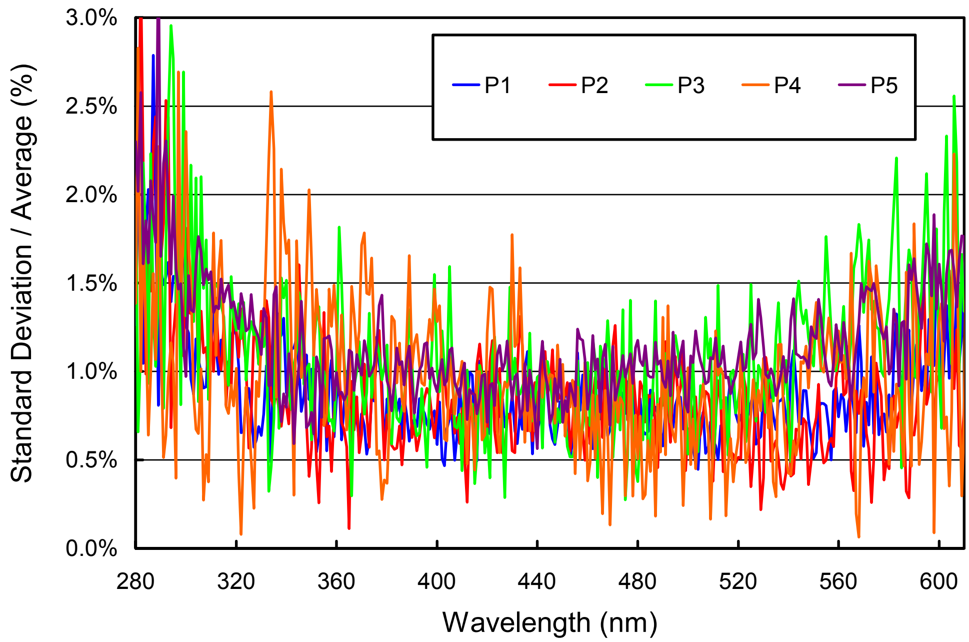


**Figure 5.3.5.** *Ratio of standard deviation and average calculated from the absolute calibration scans measured during the South Pole 2001/02 season.*

### 5.3.3. 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 5.3.6 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 380 scans were evaluated. The change in offset was smaller than ±0.035 nm for 91% of the scans. Only 4 scans (1%) had a shift larger than ±0.035 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 resulting correction functions are shown in Figure 5.3.7. Two functions were established, one for the period 1/14/01 – 2/27/01, and one for the period 2/28/01 – 1/14/02. The corrections exceed 1 nm for wavelength larger than 520 nm. The magnitude of the correction is considerably larger than typical. As mentioned above, the monochromator used during Volume 11 was an emergency replacement due to mechanical problems of the previously installed monochromator. The mechanics of the new monochromator were in excellent conditions, however, its optics proved to be slightly misaligned, causing the increased wavelength non-linearity.

After the data has been wavelength corrected using the shift-function described above, the wavelength accuracy was again tested with the Fraunhofer method. The results are shown in Figure 5.3.8 for four UV wavelengths. The residual shifts are typically smaller than ±0.05 nm except of few days at the end of February 2001. No data exist for a few days shortly before and after polar night because irradiance levels are too small for achieving a good-quality correlation during this time. The actual wavelength uncertainty may be slightly larger due to wavelength fluctuations of about ±0.02 nm throughout a given day, and possible systematic errors of the Fraunhofer-correlation method (see Section 4.2.2.2).

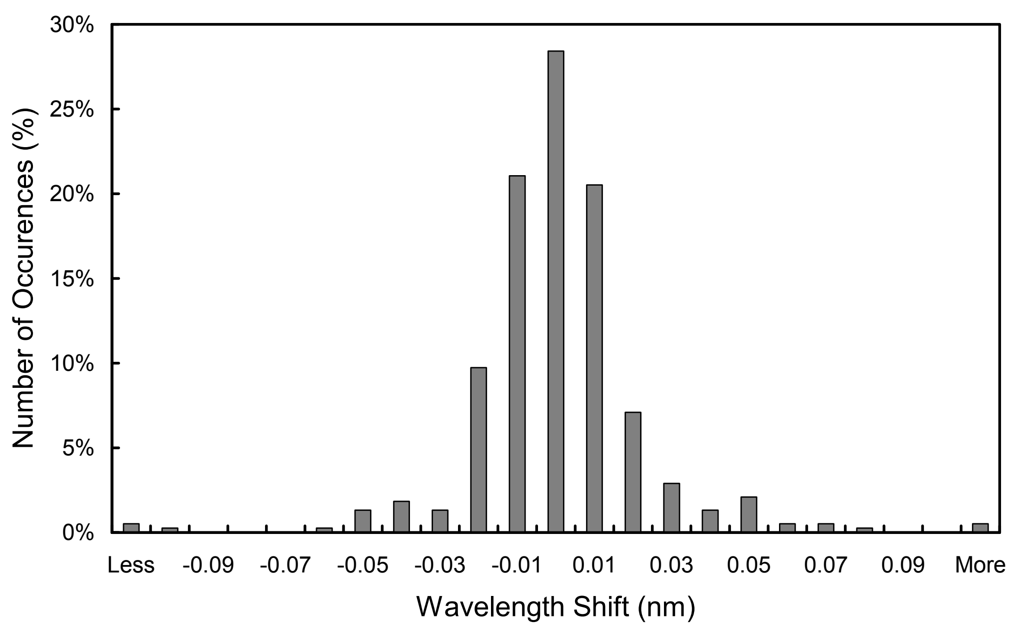


**Figure 5.3.6.** *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

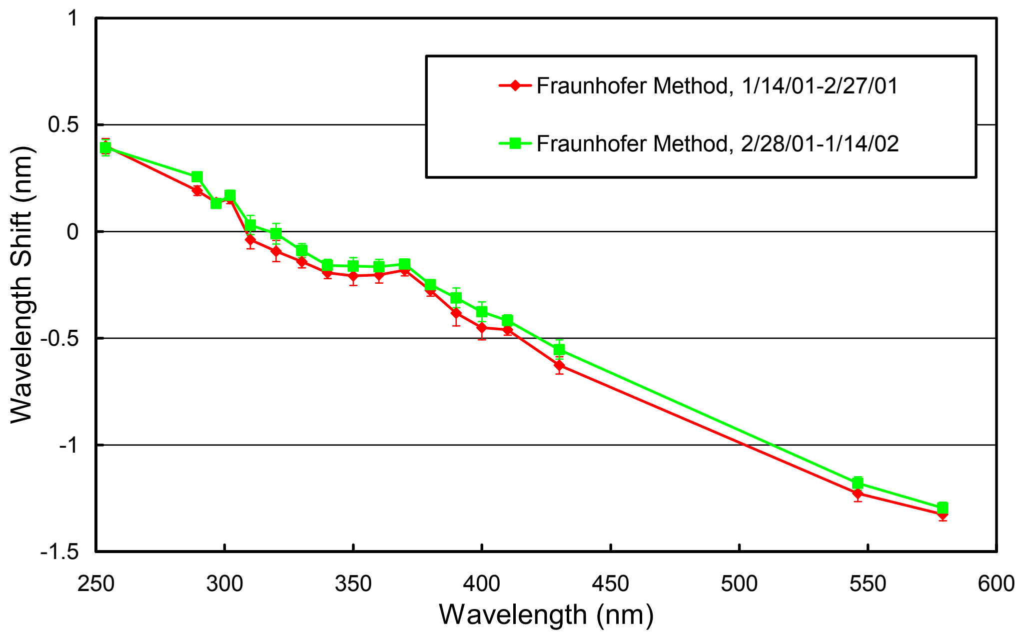


**Figure 5.3.7.** *Monochromator non-linearity functions for the South Pole 2001/02 season. The error bars show the 1σ standard deviation of the wavelength shifts.*

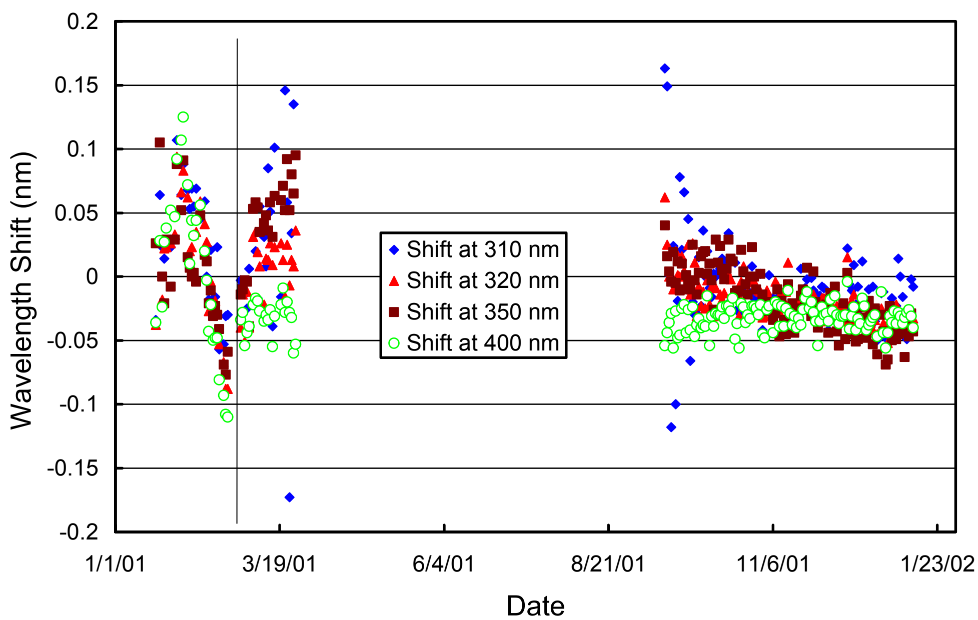


**Figure 5.3.8.** *Wavelength accuracy check of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season. No data exist during polar night.*

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 5.3.9 illustrates the difference between internal and external mercury scans collected during both site visits. There is a significant difference between the external mercury scans recorded before and after the system service in January 2001 (compare external scan labeled "External Vol 10 Jan 2001" with scan labeled "External Vol 11 Jan 2001"). As mentioned before, the monochromator installed during this site visit was not correctly aligned leading to a larger than usual "foot" for external scans. Internal scans were only little affected by the misalignment.

Peaks of the internal and external scans are shifted by approximately 0.13 nm to shorter wavelengths. External scans have a bandwidth of about 1.03 nm FWHM, whereas the bandwidth of the internal scan is only 0.74 nm. Since external scans have the same light path as solar measurements, they more realistically represent the monochromator bandpass relevant for solar scans.

A wider foot of the instrument's slit function leads to an overestimation of the solar spectrum at short wavelengths. This effect was quantified by convolving a high-resolution model spectrum with a typical slit function and a modified slit function with a wider foot. The effect on erythemal irradiance was found to be smaller than 0.2%. Volume 11 solar data are therefore not significantly affected by the misaligned monochromator.

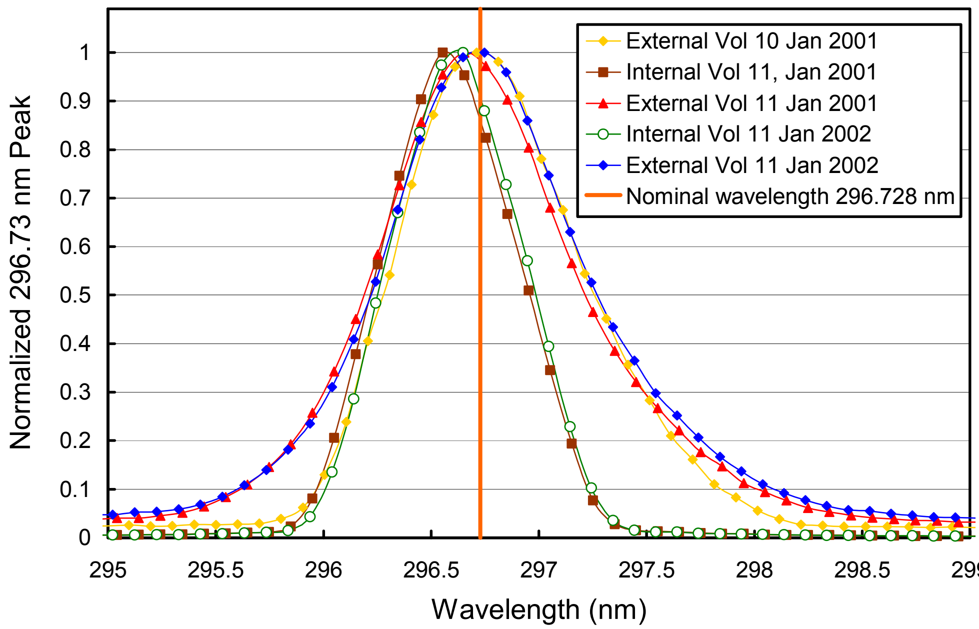


**Figure 5.3.9.** *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements, i.e., it is based on a combination of internal scans and the Fraunhofer-correlation method.*

### 5.3.4. Missing Data

A total of 16645 scans are part of the published South Pole Volume 11 dataset. These are more than 92% of all scans scheduled. Of the missing scans, 64, 372, and 183 were superseded by absolute, wavelength, and response scans, respectively. Since South Pole Station has 24 hours of sunlight per day during the austral summer, a loss of data scans cannot be avoided. Because of technical problems 3.5% of the scheduled scans are missing. A total of 590 scans was lost due to computer lock-ups as explained in the introduction to Section 5.3. The following days are affected; numbers in parentheses give the number of missing scans: 1/30/01 (49), 1/31/01 (5), 2/3/01 (6), 2/8/01 (72), 2/9/01 (4), 2/10/01 (66), 2/11/01 (7), 2/23/01 (51), 2/24/01 (4), 2/24/01 (78), 2/25/01 (73), 2/26/01 (4), 2/27/01 (64), 3/5/01 (37), 3/6/01 (6), 3/18/01 (56), and 3/19/01 (7). On 1/21/01, the computer scheduled the next scan too far ahead of time, and consequently 23 scans were lost. Removal of ice underneath the collector on 10/28/01 lead to the loss of 8 scans.