5.3. Amundsen-Scott South Pole Station (1/26/00–1/12/01)

The 2000-2001 season at Amundsen-Scott South Pole Station is defined as the time between the site visits 1/16/00 – 1/25/00 and 1/12/01-1/19/01. The season opening and closing calibrations were performed on 1/25/00 and 1/12/01, respectively. Volume 10 solar data comprise the period 1/26/00–1/12/01. 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. The spectroradiometer's monochromator was replaced during the same site visit. About 93% of the scheduled data scans are part of the published dataset. Except of the problems described in the following, the system performed well:

- **System time errors**
  The computer time was not adjusted by the GPS receiver between 1/26/00 and 3/28/00 due to an incorrect value in the software configuration. The latter day marks also the beginning of the reduced scanning schedule during polar night, when only one data scan per day is recorded. The GPS reading on 3/28/00 indicated that the computer clock was fast by 3546 seconds. This suggests that the system time advanced by one hour someday between 1/26/00 and 3/28/00. The exact day of this time reset could not be determined. It appears, however, that the time on 3/11/00 was still correct. This can be concluded by comparing the times of day when the masts installed at the ARO building cast a shadow on the instrument's diffuser. The times in 2000 agreed with those in 1999 until 3/11/00. For example, the spectral measurements at 340 nm show a distinct decrease at 06:00 and 06:15 GMT both in 1999 and 2000. Similar drops in the signal can also be found at 13:45 GMT during both years. After 3/11/00, clouds and the low solar elevation prevent the application of this method.

  The wrong configuration parameter was unfortunately not discovered until the next site visit in January 2001. As a consequence, the system time was not adjusted as frequently as necessary also in the second part of the year. However, time errors between October 2000 and January 2001 never exceeded more than 60 seconds:
  - The system time was set correctly when measurements resumed after the polar night on 9/15/00.
  - After that time, the GPS was not updating the time until 11/19/00. The reading on this day indicated that the clock was slow by 60 seconds.
  - After the time was adjusted on 11/19/00 the time was not corrected until 12/31/00, when the time was found to be off by 3 seconds.
  - The time before start of the site visit in January 2001 was correct to within few seconds.

  Published solar data were not corrected for these time errors. For most studies even a time error of one hour is of minor importance since the solar zenith angle at the South Pole does virtually not change during one day. For example, a one our time error on 3/28/00 corresponds to a difference in solar elevation of 0.016° only. However, when SUV-100 measurements are compared to other radiometers that might have been deployed at the South Pole during the affected period, adjustments may be necessary.

- **Ice build-up under the collector**
  Between 11/26/00 and 12/14/00, moisture was freezing underneath the collector and changed the throughput by 6%. The problem and its correction are described in detail in Section 5.3.2.

- **Wavelength offset**
  Between 12/31/00 and 01/06/01 the wavelength alignment was off by 20 nm. A wavelength shift of this magnitude cannot be corrected. Solar data from the affected period had to be discarded.

During the site visit in January 2001, the PSP and TUVR instruments installed at South Pole were replaced by identical instruments, which had been calibrated recently by Eppley. The previously installed instruments were sent to Eppley for recalibration. The new calibration factors were applied to the data of the Volume 10 season. New and old calibration factors deviate by 2.4% for the PSP and by 9.2% for the TUVR. If the old calibration factors were used, published solar data of the PSP would be lower and data of the TUVR would be higher.

5.3.1. Irradiance Calibration

The site irradiance standards for the 2000/01 South Pole season were the lamps 200W006, 200W021, and M-666. Lamp M-874 was used as the traveling standard at the beginning of the season (It was calibrated by Optronic Laboratories in September 1998). The traveling standard at the end of season was M-764. The calibration of this lamp was established by Optronic Laboratories in October 1992 and checked in March 2001. See the introduction to Chapter 5 for further explanation.

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.

Figure 5.3.1 shows a comparison of 200W006, 200W021, and M-666 with M-874 at the start of the season (1/25/00). The figure indicates that all site standards agree with each other to within ±0.5%. The deviation to the traveling standard M-874 is smaller than ±1.5%. 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 and the traveling standard M-764.

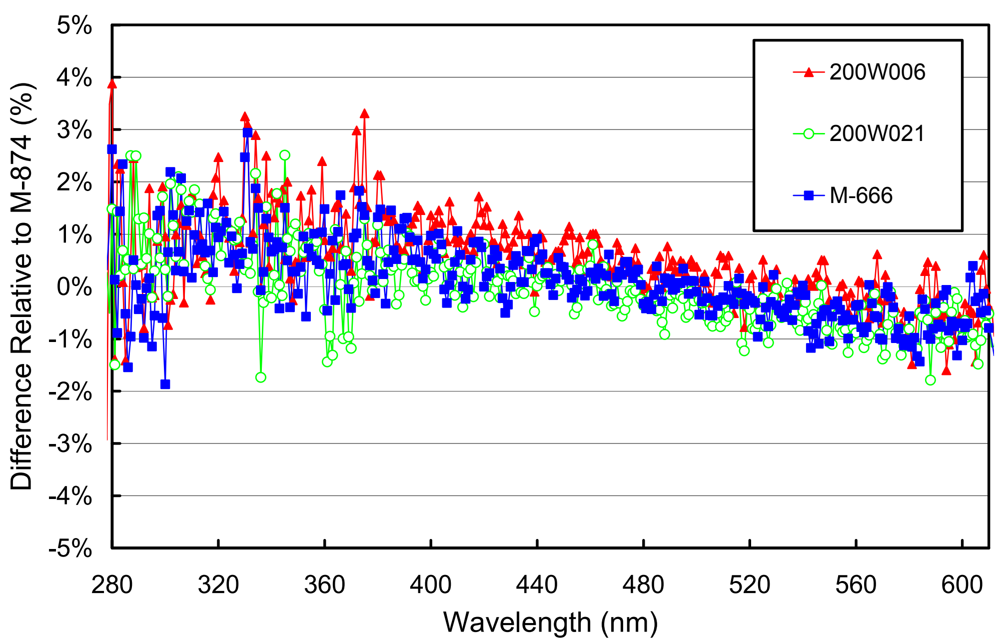

Figure 5.3.1. *Comparison of South Pole lamps 200W006, 200W021, and M-666 with the BSI traveling standard M-874 at the start of the season on 1/25/00.*

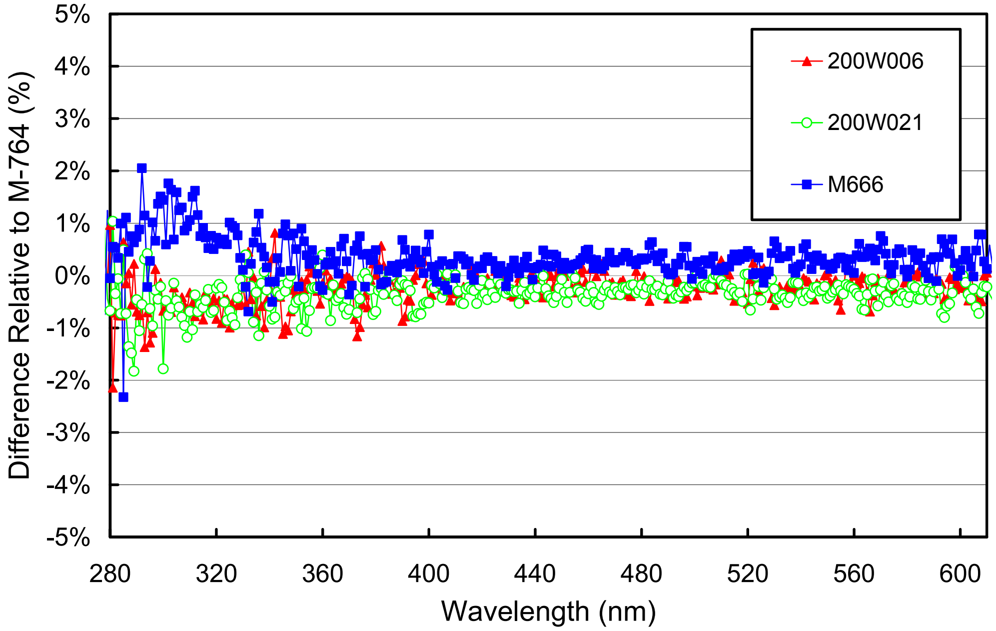

Figure 5.3.2. *Comparison of South Pole lamps 200W006, 200W021,M-666 with the BSI traveling standard M-874 at the end of the season on 1/12/01.*

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. 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 5.3.3 shows the changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily response scans of the South Pole 2000/01 season. The TSI measurements show that the internal lamp was stable to within ±1% during the whole season. The PMT currents at 300 and 400 nm suggest that monochromator and PMT were stable to within ±2.5%.

Changes in the fore-optics cannot be detected with response scans. As mentioned above, there was ice build-up underneath the collector between 11/26/00 and 12/14/01, which changed the responsivity of the system. This change can clearly be seen in absolute calibrations performed during this period. Figure 5.3.4 shows absolute calibrations performed between 11/4/00 and 12/18/00, referenced to the average of the two calibrations conducted at the beginning of the period (11/4/00 and 11/19/00). As can be seen, the calibration on 12/03/00 is different from these calibrations by 6%, and that on 12/7/00 is higher by 7%, independent of wavelength. Calibrations performed on 12/14/00 and 12/18/00, which were performed after the problem was solved, nicely agree with the initial scans.

The effect of the ice build-up could clearly be seen in solar data before they were corrected. Figure 5.3.5 shows a dip in solar spectral irradiance at 340 nm in uncorrected data between 11/26/00 and 12/14/01. The solid line indicates the expected clear sky irradiance. The line was made up using the information from the absolute scans, which indicated that no correction is necessary before 11/25/00 and after 12/15/01, and that the correction on 12/14/00 and 12/18/00 should be 6% and 7% respectively. Our procedure of data processing allows only a change of calibration from one day to another but not with in one day. The smooth function plotted in Figure 5.3.5 was therefore translated into a step function with changes occurring every 1-3 days. This correction function is also plotted in Figure 5.3.5. The correction was implemented by scaling the spectrum assigned to the internal reference lamp during Period 3 (see below) by this function. We believe that this correction is accurate to within ±2%, independent of wavelength.

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 five periods, denoted Periods 1 to 5. Period 1 includes all solar scans performed before the polar night. The irradiance assigned to the internal lamp was calculated separately for all periods following the procedure described in Section 4.2.1.2. Figure 5.3.6 shows the ratios of the irradiance assigned to the internal lamp in the different periods referenced to the spectrum applied in Period 1. There is a change of 2% between Period 1 and Period 2. This indicates that the system's responsivity had changed by 2% during the polar night.
Figure 5.3.7 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 less than 1% for wavelengths above 300 nm in all periods, confirming the good stability of the calibrations.

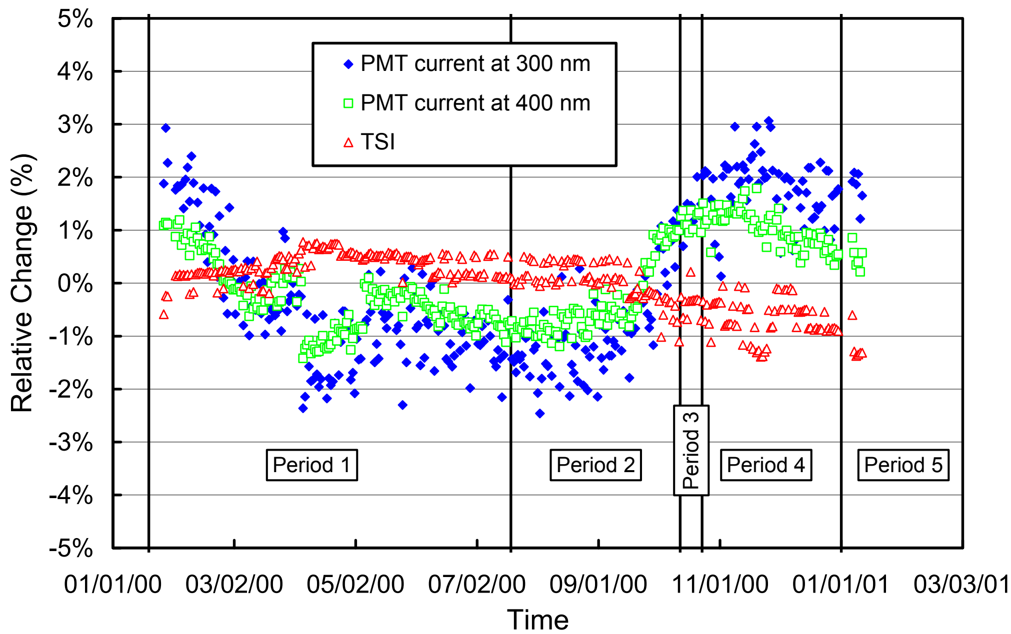

Figure 5.3.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal during measurements of the internal irradiance standard performed during the South Pole 2000/01 season. The data are normalized to the average of the whole period.*

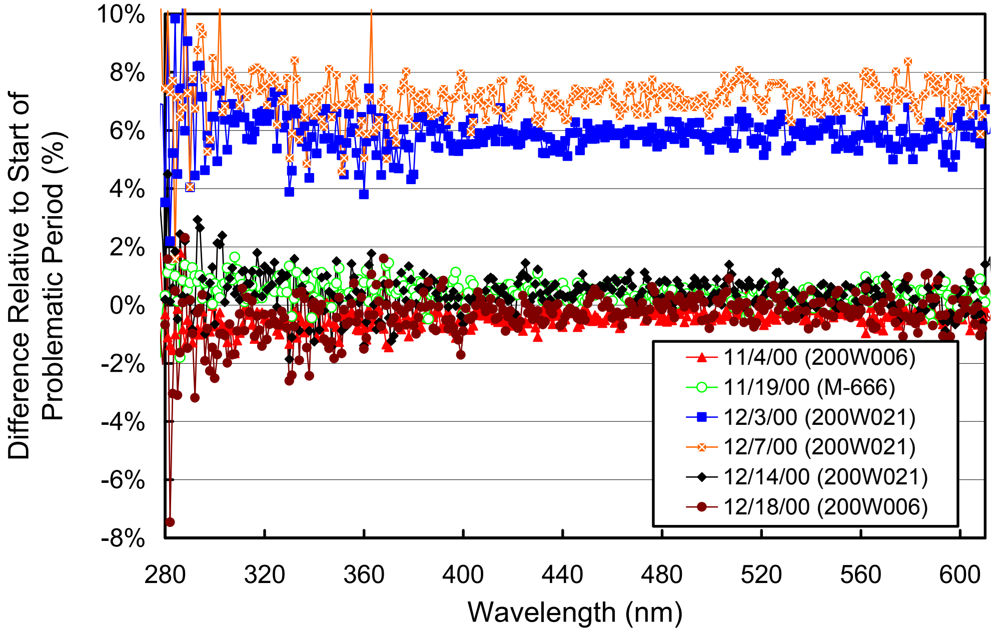

Figure 5.3.4. *Comparison of absolute calibrations at South Pole performed between 11/4/00 and 12/18/00.*

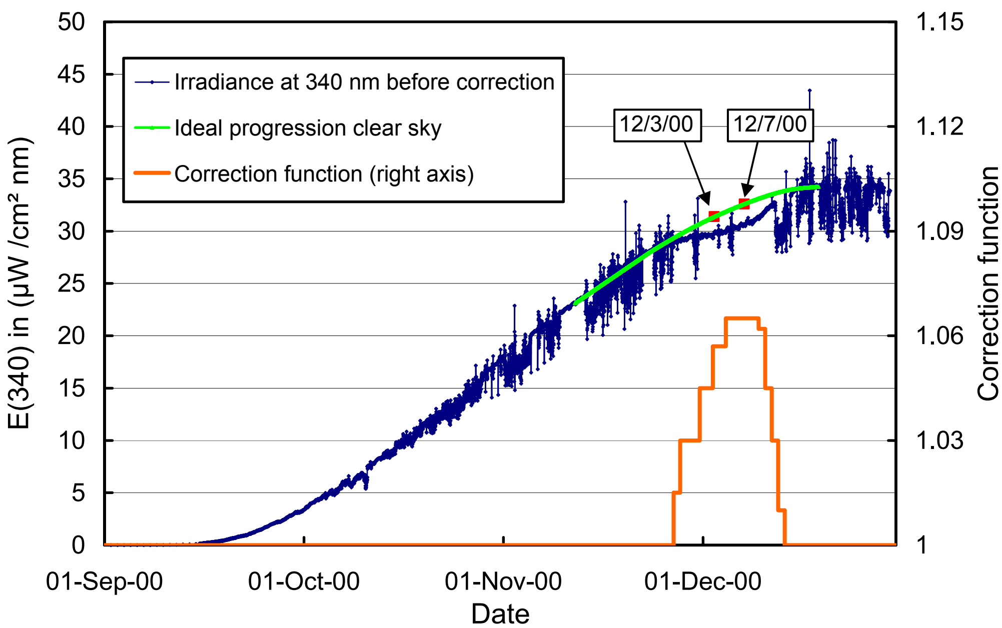

Figure 5.3.5. *Effect of the ice build-up underneath the collector on solar irradiance at 340 nm.*

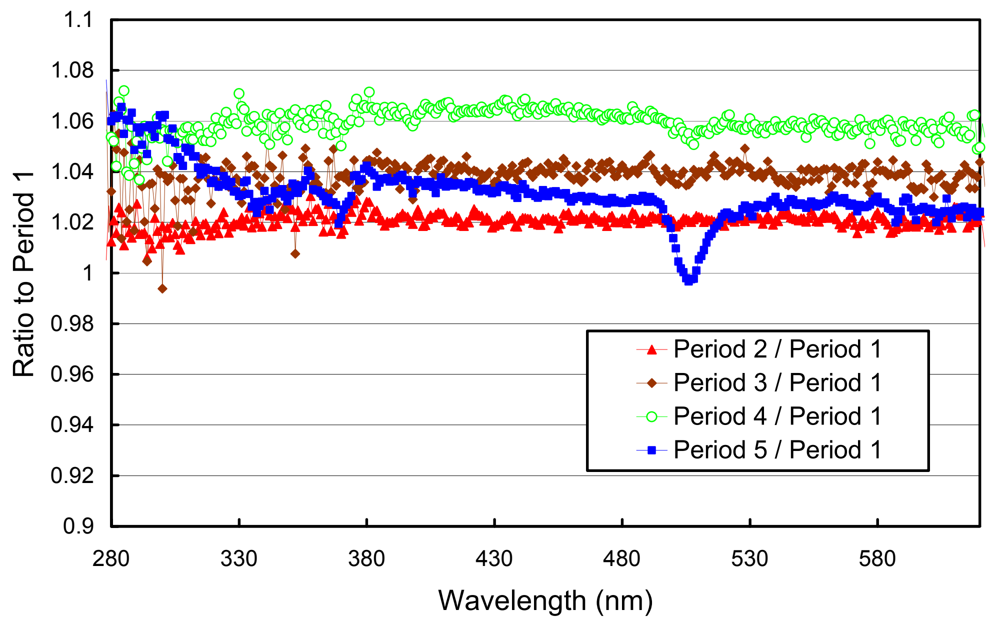

Figure 5.3.6. *Ratios of the irradiance assigned to the internal lamp in Periods 2 – 4, relative to Period 1.*

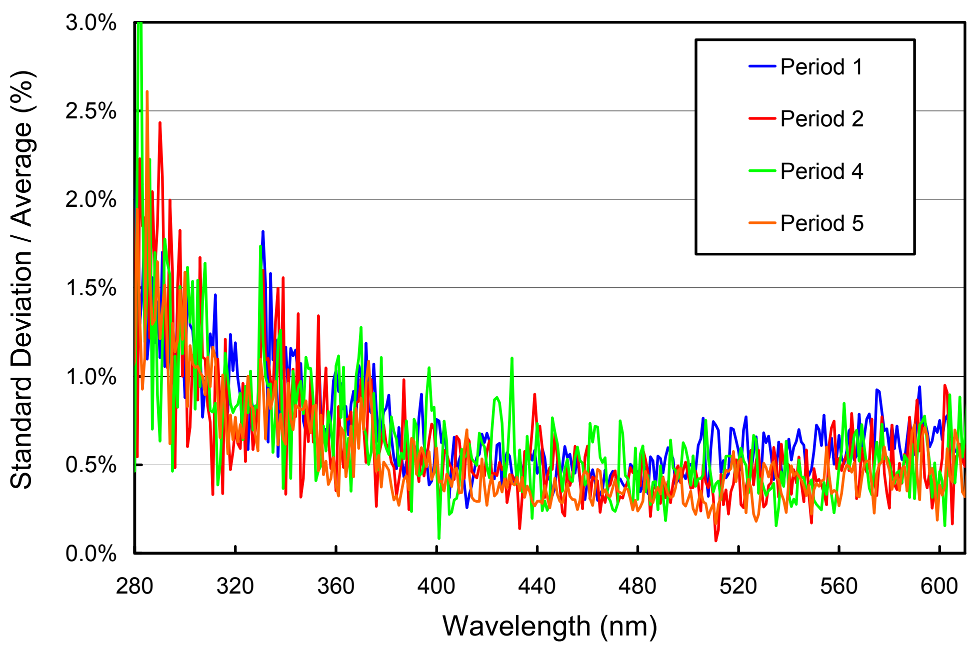

Figure 5.3.7. *Ratio of standard deviation and average calculated from the absolute calibration scans measured during the South Pole 2000/01 season.*

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 5.3.8 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 367 scans were evaluated. For 93% of the scans, the change in offset was smaller than ±0.035 nm. However, there was a change in the wavelength offset of 20 nm occurring at the end of 12/30/00. The problem was not discovered until 1/6/01. Since a wavelength offset of this magnitude cannot be corrected, the first week of data in 2001 was lost.

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. During the analysis it appeared that the monochromator's wavelength tracking changed slightly during the year. Therefore, four difference correction functions were applied for the periods 1/19/00 – 10/20/00, 10/21/00 – 10/25/00, 12/16/00 – 12/31/00, and 01/01/01– 01/13/01. These functions are shown in Figure 5.3.9. For comparison purposes, the figure also includes the correction function that was calculated with the "old" wavelength correction method, which was based on internal wavelength scans only. The average difference between the four correction functions calculated with the new Fraunhofer correlation method and the previous method is approximately 0.09 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 has been wavelength corrected using the shift-function described above, the wavelength accuracy was tested again with the Fraunhofer method. The results are shown in Figure 5.3.10 for four UV wavelengths. The residual shifts are generally smaller than ±0.05 nm. No data exist for 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).

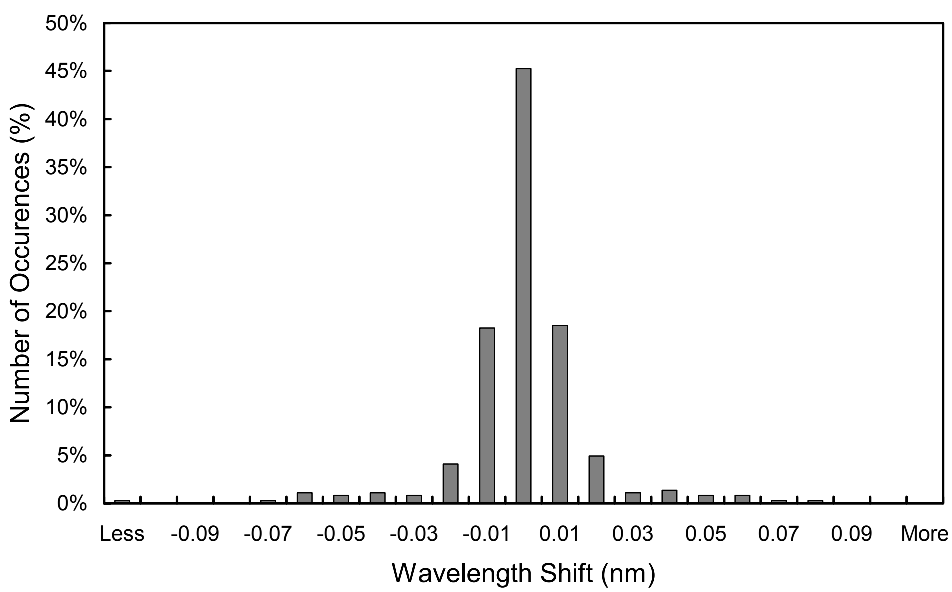

Figure 5.3.8. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

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 5.3.11 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 peaks of the external scans agree well with the nominal wavelength of 296.73 nm, whereas the peak of the internal scans is shifted about 0.14 nm to shorter wavelengths. External scans have a bandwidth of about 1.00 nm FWHM, whereas the bandwidth of the internal scan is only 0.72 nm. Since external scans have the same light path as solar measurements, they more realistically represent the monochromator bandpass relevant for solar scans. Note that internal and external mercury scans of Volume 9 and 10 have a slightly different pattern, because of the monochromator replacement and the collector modification performed during the site visit in 2000.

5.3.4. Missing Data

A total of 16235 scans are part of the published South Pole Volume 10 dataset, which are 93% of all scans scheduled. Of the missing scans, 72, 214, and 182 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. 531 (3%) scans were lost between 12/30/00 and 1/6/01 when the wavelength was misaligned by 20 nm. Approximately 110 scans were excluded from the published dataset at various days when masts of the ARO building cast a shadow on the collector. In total, 3.5% of all scans were lost because of technical problems.

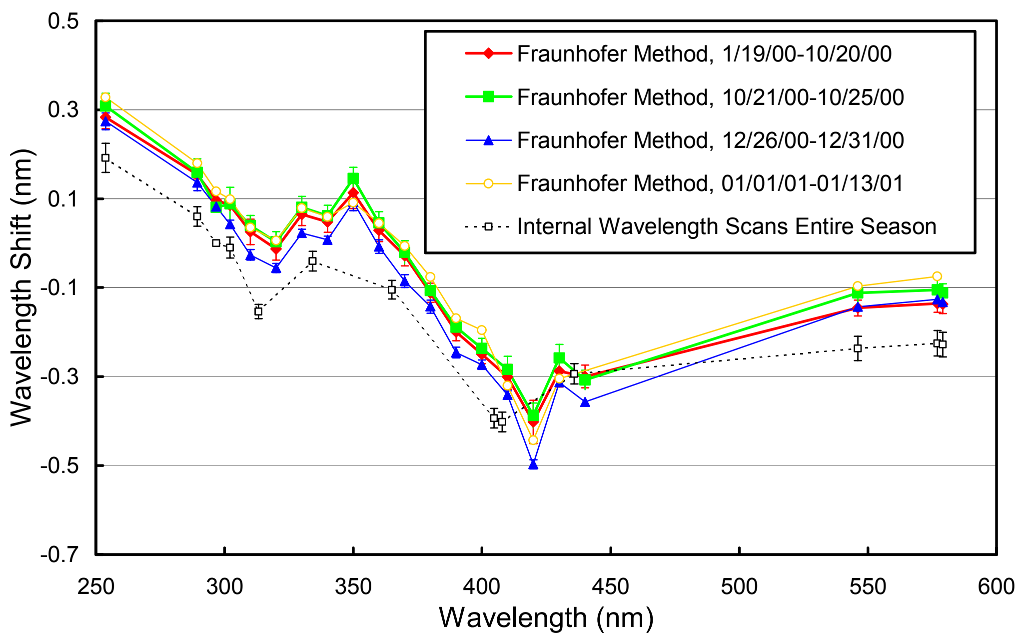

Figure 5.3.9. *Monochromator non-linearity functions for the South Pole 2000/01 season. Thick lines: Correction functions calculated with the Fraunhofer-correlation method, applied to correct the South Pole Volume 10 data. Thin broken line: Correction function calculated with the method that was historically applied. The error bars show the 1σ standard deviation of the wavelength shifts.*

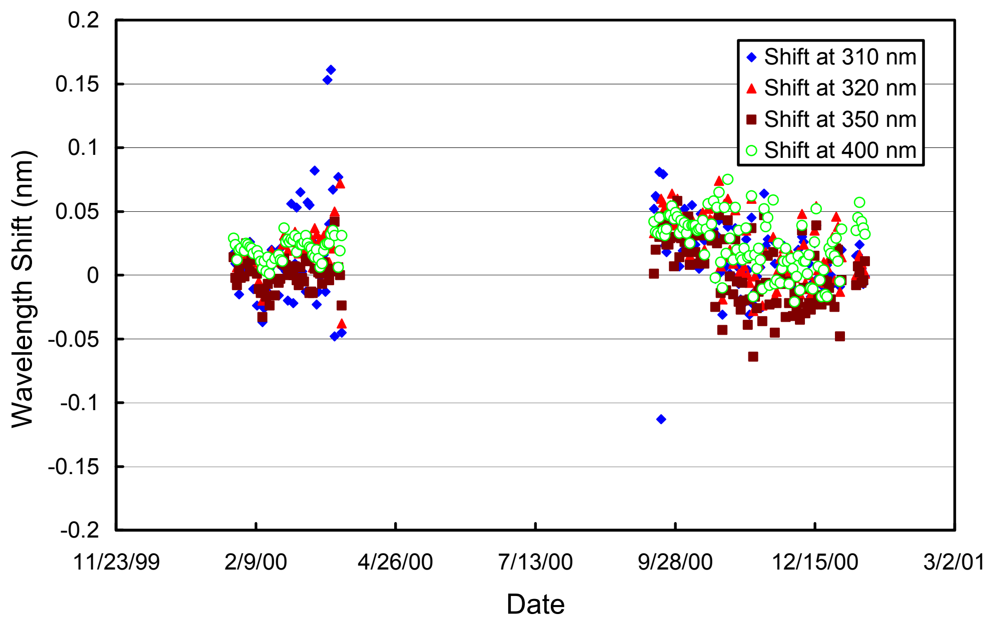

Figure 5.3.10. *Wavelength accuracy check of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season. No data exist during polar night.*

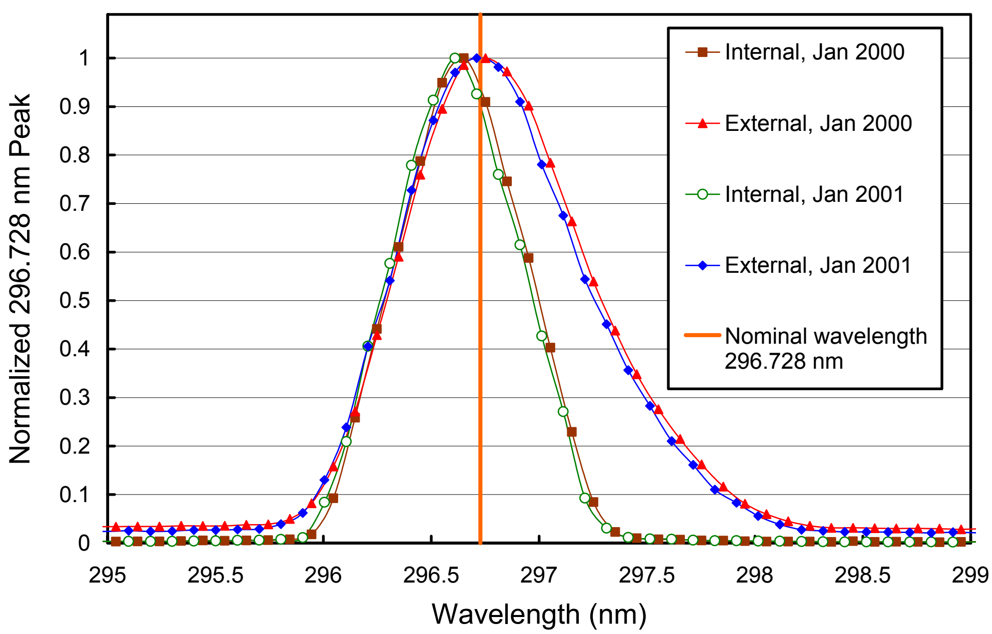

Figure 5.3.11. *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements, i.e., it is based on a combination of internal scans and the Fraunhofer-correlation method.*