Periods with Increased Uncertainty

Measurements

Version 2 Barrow measurements of several periods are affected by instrumental or operational problems and have larger (but usually difficult to quantify) uncertainties than those specified in the uncertainty budget of the main paper. Descriptions of some problems were adapted from Network Operations Reports and are indicated in the list below with the prefix "Operations Report." Other problems were discovered during quality control of processed Version 2 data.

- **Volume 2 (1991):**
  - Operations Report:
    - Data of the period 2/22/91 – 3/5/91 have increased uncertainty due to a failure of the instrument's shutter and the inability to run response scans during daylight hours (1991-1992 Operations Report, page 111).
    - Data of the periods 3/6/91 – 4/17/91 have increased uncertainty due to a failure and eventual replacement of the internal 45-W lamp (1991-1992 Operations Report, page 112).
    - Differences between consecutive calibration files were as high as 4% in May and June 1991 (1991-1993 Operations Report, page 160).
  - Version 2 quality control; comparison of measurement and model: Measurements performed between summer and autumn of 1991 (June – September) are low by 5-15% compared to data other volumes. In particular the period 6/20/91 – 7/1/91 is affected. Data of this period should not be used for trend analysis.
- **Volume 3 (1992):**
  - Operations Report: The collector was not cleaned on a regular basis in 1992. In particular data collected during the second half of the year (mid-June – December) are affected. Systematic errors in the UV may be as high as 4% (1991-1993 Operations Report, pages 162-163).
- **Volume 4 (1993):**
  - Operations Report: The collector was not cleaned on a regular basis in 1993, in particular during the first half of the year (Feb – mid-June). Collector contamination may have reduced irradiance by as much as 7% at 300 nm, 4% at 350 nm, and 2% in the visible (1993-1994 Operations Report, page 121).
  - Version 2 quality control; comparison measurement and model: Data from March 1993 were high by 5-7% on average and suffered from a comparatively large uncorrected azimuth error. Data from March 1993 should not be used for trend analysis.
- **Volumes 2 – 4 (Start – 11/15/93):**

  The cosine diffuser installed until 11/15/93 was partly transparent in the visible. The diffuser had a substantial, wavelength-dependent cosine error for wavelengths longer than 500 nm, which could not be corrected. Due to this problem, also the effect of the monochromator's Wood's anomaly at 505 nm was not corrected. Data with wavelengths above 490 nm should not be used for any purpose.

- **Volume 5A (1/27/94 – 6/9/94):**
  - Site visit report and Version 2 quality control: A different monochromator was installed during this period. The system's cosine-error with this monochromator in place was difficult to determine due to an insufficient number of clear sky spectra. Data analysis indicated that the cosine error of this period was significantly different from that of Volumes 5B – 9.
  - Version 2 quality control: Final Volume 5A spectra are consistent to within ± 3% with spectra of other volumes. However, there is a 3.5% step between 493 and 495 nm in Volume 5A spectra relative to spectra of other volumes. This step is partly an artifact of the insufficiently accurate correction of the monochromator's Wood's anomaly around 500 nm.

    Data measured between 2/15/94 and 2/26/94 appear to be too high in the visible and have some unexplained wavelength dependence. Data of this period should not be used.
  - Operations Report and site visit report:
    - During the Volume 5A period, the instrument also suffered from excessive heat because hot air produced by the system's thermo-electric cooler (TECA) was not released from the room where the instrument is located. The efficiency of the cooler was therefore reduced, leading to high temperatures in the instrument enclosure. High temperature and its variability also affected response scans. Six calibrations were applied between 2/2/94 and 6/10/94 with 2-3% changes between individual calibrations.
    - Absolute scans showed relatively large drifts. The effect on solar data should be small because the instrument's calibration was adjusted accordingly.
    - The monochromator was re-positioned on 2/1/94. This should not affect solar data because the calibration was adjusted.
- **Volume 7 (1997-1998):**

  Operations Report: Periods with increased uncertainty of Volume 7 include:
  5/18/98 – 6/5/98 (monochromator temperature high by 6°).
  6/23/98 – 7/18/98 (photomultiplier cooler defective).
- **Volume 9 (2000):**
  - Operations Report: Large drifts in responsivity were caused by changes in monochromator bandpath and by the accumulation of residue on the relay lens. The additional 1σ-uncertainty of solar data remained below 2% due to frequent adjustment of calibration files (1999-2000 Operations Report, table 5.6.1).
  - Version 2 quality control: Measurements between 5/15/00 and 5/17/00 9:15 look suspicious. Spectra were calibrated with an interpolated calibration file.
- **Volume 10 (2001; first season with upgraded cosine collector):**

  Operations Report: Large changes in responsivity were caused by abraded paint from the instrument's shutter. Due to frequent adjustment of calibration files, the drift-related uncertainty typically remained below 1.5% in the UV-B, but was as high as 2.9% during one period (2000-2001 Operations Report, table 5.6.1).

- **Volume 14 (2004/2005):**

  Operations Report: The temperature inside the instrument enclosure frequently exceeded the set value of 28.5 °C by more than 5 °C. Likewise, the temperature of the monochromator was often more than 5 °C above the set point. (In normal operation, the temperature of the monochromator is stable to within ±0.5 °C). Excess temperature was caused by insufficient air-conditioning in the laboratory below the instrument.

  Comparisons of SUV-100 measurements with the collocated GUV-511 multichannel radiometer indicated that SUV-100 measurements at 340 nm were low by up to 20% during periods with excess temperature. When the monochromator temperature was stable at 33±0.5 °C, GUV-511 and SUV-100 measurements typically agreed to within ±5%. When the temperature rose to 39.8 °C on 7/25/05, GUV-511 readings were 15% higher than SUV-100 measurements. Affected data are indicated in Table 1. Associated Version 2 data were flagged and should not be used.

Table 1. Periods affected by systematic errors in SUV-100 data in 2004 and 2005.

Period	Systematic error at 340 nm	Reason
05/17/04 13:00 - 05/20/04 16:00	SUV low by up to 14%.	High temperature
06/20/04 19:45 - 06/21/04 00:45	SUV low by up to 14%	High temperature
06/26/04 12:00 - 06/26/04 19:00	SUV low by up to 20%.	Unknown
06/28/04 03:30 - 06/28/04 12:30	SUV low by up to 9%	High temperature
07/04/04 23:30 - 07/05/04 09:00	SUV low by up to 9%.	High temperature
07/07/04 05:00 - 07/07/04 14:30	SUV low by up to 11%.	Unknown
07/24/04 23:15 - 07/25/04 23:45	SUV low by up to 15%.	High temperature
08/13/04 11:45 - 08/19/04 00:00	SUV low by up to 15%.	High temperature
04/29/05 20:00 - 04/30/05 09:00	SUV low by up to 16%.	High temperature

- **Volume 15 (2005/2006):**
  - Operations Report:
    - The temperature inside the instrument enclosure exceeded the set value on several occasions and this also affected the temperature stabilization of the monochromator. In April 2006, the temperature regulation of the instrument enclosure failed and could not be repaired before 6/16/06. From 4/17/06 to 5/2/06, monochromator temperatures fluctuated between 33.5° and 38.5°, but remained stable to within ±0.5° for the remainder of affected period.
    - On 7/31/06, there was a building-wide power outage and also the laboratory's air-conditioning was not working on this day. As a consequence, temperatures in the SUV-100 enclosure reached up to 49°C. Solar data tend to be low when monochromator temperature is high.
    - The system's High Resolution Analog to Digital Converter (HRAD failed on 3/7/06, was sent to BSI for repair, and reinstalled on 3/23/06. Spectral

irradiance data from the affected period are restricted to the wavelength range 280 - 344 nm.

- The PMT is cooled to a temperature of -3 °C. The cooler's fuse was blown between 7/30/06 and 8/23/06. The PMT's sensitivity during this period was reduced by 8%. Published data are only little affected because the sensitivity change is tracked and corrected using the daily scans of the internal lamp.
- Operational support of the system was limited, in particular between June 2005 and March 2006. The instrument's collectors were cleaned infrequently during this period. When it was obvious that measurements were affected by dust and other contamination of the collector, data were corrected, but data uncertainty is increased during several periods.
- The internal reference lamp became brighter at an excessive, albeit predictable, rate of about 2.5% per month. On 8/21/06, the lamp became unstable and could no longer be used for tracking changes of the system's responsivity. Calibrations had to be adjusted frequently to accommodate drift and instability of the lamp. For most periods, the uncertainly of published data is only little increased.

- Comparison with GUV:
  - SUV-100 data from 9/5/05 and 9/6/05 are low by about 10%. Published data were corrected upward by 10% and 16 scans were excluded from the published data set.
  - Between 8/25/05 and 10/3/05, the ratio of GUV/SUV is abnormally low. There is no evidence that this is caused by a problem in SUV-100 data because calibrations performed during this period are stable.
  - Between 4/26/06 and 5/2/06, the ratio is affected by high monochromator temperatures, as explained above.
  - Between 7/9/06 and 7/11/06, the ratio varies between 1.04 and 1.08, for unknown reasons.
- Version 2 quality control: Between 7/20/05 and 8/1/05, the ratio of measurement and model is low by about 5% for unknown reasons.

Based on the evidence above, data of the following periods should be used with caution, and not used for trend analysis: 9/5/05, 9/6/05, 3/7/06 – 3/22/06, 4/17/06 – 5/2/06, 7/9/06 – 7/11/06, 7/31/06.

- **Volume 16 (2007):**

  Operations Report:
  - The internal reference lamp became unstable on 8/21/06 (see Volume 15 above) and could not be used from then onward for tracking changes of the system's responsivity. The lamp was replaced on 1/30/07. The signal produced by the new lamp also showed short-term fluctuations of about 10%. On 3/3/07, the lamp's random variations ceased for no apparent reason. Between March and December 2007, the lamp became steadily brighter at a rate of 1.2% per month. This rate of increase is still beyond typical changes for internal lamps, but the effect could be corrected.
  - The on-site calibration standards were not available between August and November 2007. During this period, the system was vicariously calibrated against the GUV-511

radiometer. The calibration was further assessed by comparing measurements of the SUV-100 with radiative transfer model calculations. We conclude that the uncertainty of published solar data from August to November is increased by about ±5%.

- Between 8/22/07 and 9/14/07, temperatures inside the instrument enclosure exceeded the set value by several degrees due to overheating of the laboratory located below the SUV-100. The monochromator temperature, which is normally maintained at 33 °C, exceeded 36 °C on several occasions. The maximum temperature was 40 °C. Comparisons with the GUV-511 radiometer indicate that the responsivity of the SUV-100 spectroradiometer was decreased by 30% when the temperature was 40 °C. Typical enhancement are in the range of 5-10% and could be corrected by adjusting the instrument's calibration accordingly. Periods with larger change in responsivity were excluded from the published data set.
- The wavelength indicator of the monochromator jammed on 7/21/07 and was removed on 7/27/07. Data from this period had to be discarded.

Based on the evidence above, data of the following periods should be used with caution, and not used for trend analysis: 8/23/07 – 9/1/07, 9/7/07 – 9/17/07.

- **Volume 18 (2008/2009):**

  Operations Report:

  There was no site visit by BSI personnel during this period and the level of operational support at Barrow was less than ideal. For example, only nine absolute scans were performed between August 2008 and July 2009 and the instrument's collector was only cleaned occasionally during this period. The instrument's response lamp became unstable in July 2008 and was not be replaced before March 2009. As a consequence, scans of the lamp could not be used to track and adjust changes of the system's sensitivity on a daily bases as it is done usually. Variations of the spectroradiometer's responsivity was checked, and adjusted if necessary, using data of the site's GUV-511 multifilter radiometer. The calibration of this instrument proved to be very stable during this period. The uncertainty of data from the period when the vicarious GUV-based calibration was applied is increased by about ±5%. Data of the following periods should be used with caution, and not used for trend analysis: 2/19/08 – 2/20/08, 4/6/08, 6/15/08, 6/21/08, 7/23/08, 8/6/08, 8/11/08, 8/20/08, 5/31/09, 6/4/09, 6/6/09, 6/7/09, 7/11/09.

- **Volume 19 (second half of 2009):**

  Operations Report: The system ran all but unattended 4/17/09 and 3/3/10 due to a breakdown in support contract arrangements. No calibration scans could be performed during this period and the instrument's collector was only cleaned occasionally. The system was regularly checked from BSI using remote-access software. The unfortunate support situation led to reduced data yields and increased uncertainty, however, no catastrophic system failure occurred and a good fraction of the data could be salvaged and published. As no absolute scans were performed between 4/17/09 and 3/4/10, the radiometric calibration for this period is uncertain. Drifts of the SUV-100 spectroradiometer were assessed by comparing SUV-100 measurements with radiative transfer model calculations. For years prior to 2009, measurements of the SUV-100 during clear sky periods typically agreed to within a few percent with the model when the input parameters of the model were well defined. This is usually the case during summer when the surface albedo is very low. Between July and September 2009, the SUV-100 measurements were lower than the model

by 15% at 320 nm, 10% at 370 nm, 7% at 400 nm, 6% at 450 nm, 4% at 500 nm and 590 nm. All measurements performed between 7/13/09 and 11/28/10 were scaled up by this amount as part of Version 2 processing. There were no clear sky days in October and November 2009 to test whether the scaling was also appropriate for these two months. Because of the calibration uncertainty, all Volume 19 data (period 7/13/09 – 11/27/09) should not be used for trend analysis.

- **Volume 20 (2010):**
  Operations Report:
  - As explained above, the system ran all but unattended 4/17/09 and 3/3/10 due to a breakdown in support contract arrangements. Measurements up to 3/3/10 therefore should not be used for trend analysis.
  - The instrument's thermoelectric cooler failed sometime in 2009, leading to excessive instrument temperatures during July and August 2009, and March-June 2010. Also the temperature of the system's monochromator exceeded its set value of 33 °C during several days during this period, leading to reduced system responsivity. Data of periods most affected by the problem were removed from the published data set. Data of the following periods may also be affected and should not be used for trend analysis: 3/26/10 – 4/15/10, 4/21/10 – 4/25/10, 5/21/10 – 6/22/10.

Model Calculations

Model calculations of some periods were problematic due to an insufficient number of clear-sky days, which are required for calculating surface albedo. The following periods are affected:

- **Volume 2 (1991):**
  Model albedo problematic between 10/6/91 and 10/20/91.
- **Volume 5B (1994):**
  Model albedo likely too small between 9/28/94 and 10/15/94.
- **Volume 11 (2002):**
  Model albedo likely too small in January and March 2002.