1. McMurdo Station (08/15/23 – 04/30/24)

Solar data of the SUV-100 spectroradiometer discussed in this quality control (QC) report were measured between 08/15/23 and 04/30/24, and were assigned to Volume 33. There was no site visit during the reporting period. The system was very stable and performed normally, with the exception of the following issues:

- Instead of performing four scans per hour as in the past, the system only measured three scans per hour (indexed at the hour, and 20 and 40 minutes past the hour.) The reduced schedule was the consequence of a "major" upgrade of the Windows 10 Operating System on 12/31/20 as described in the Volume 30 QC report. A solution to this problem has been implemented in February 2023 for the system at the South Pole and a similar solution will be implemented at McMurdo soon. It is anticipated that the regular schedule of four scans per hour will resume for the 2024/25 data period.
- Like during the previous few seasons, the wavelength stability was degraded, requiring frequent adjustment of the system's wavelength registration during post-processing.
- The system's GPS receiver, which has been used to automatically update the computer time, failed on 1/14/20 (during the Volume 29 reporting period). From that time onward, the computer's clock has been checked and adjusted manually. The clock of the system PC is fortunately very stable. Hence, time errors in published data remain negligible. A replacement of the GPS receiver that is compatible with the system is not available.

The datasets consists of 12,427 solar spectra, which are fewer than typical due to the reduce duty cycle. The system's PSP radiometer was unit 32760F3 and has a calibration factor of 7.501 x10^{-6} V/(W m^{-2}). Data of the collocated TUVR radiometer were erratic and were not published.

1.1. Irradiance Calibration

On-site irradiance standards available during the reporting period were the lamps M-543, 200W011, 200W019, 200WN007, and 200WN008. Lamps M-543, 200W011, and 200W019 are "working standards" and are used on a regular basis. Lamps 200WN007 and 200WN008 were left at McMurdo in January 2014. Both lamps are designated "long-term" standards and are typically only used during site visits unless no site visit is performed as it was the case during the reporting period. Lamp 200WN007 was used thrice and lamp 200WN008 was used twice during the reporting period.

A comparison of the scale of spectral irradiance of lamp 200W011 with that of the other lamps suggested that this lamp has slightly (<1%) drifted relative to the other working and long-term standards. The lamp was therefore recalibrated against the long-term standard 200WN007. The scales of the working standards 200W019 and M543 were the same as those applied during the previous six season (Volumes 27–32), specifically:

- 200W019 had been recalibrated on 6/11/18 against the scale of the two long-term standards 200WN007 and 200WN008.
- Lamp M543 had been recalibrated on 8/8/16 against the working standard 200W011.

<u>Traceability of long-term standards 200WN007 and 200WN008</u>
Lamps 200WN007 and 200WN008 were calibrated by CUCF in August 2013 against lamps 200WN001 and 200WN002. The latter two lamps had in turn been calibrated by Biospherical Instruments in November 2012 against the NIST standard F-616 using a multi-filter transfer radiometer. NIST standard F-616 is traceable to the detector-based scale of irradiance established by NIST in 2000. At the time when lamps 200WN001 and 200WN002 were calibrated, they were also compared with the long-term traveling standard 200W017 of the NSF UV monitoring network. The irradiance scales of NIST standard F-616 and lamp 200W017 agreed to within 0.3%.

In early 2020, the chain of calibrations applied between 1996 and 2019 to solar data of the NSF and NOAA monitoring networks was re-evaluated (Bernhard and Stierle, 2020). This analysis suggested that the scale of spectral irradiance of NIST standard F-616 is low compared to the scale of primary standards used before 2013. This bias is –2% at 300 nm, –1% at 375 nm, and less than ±0.5% between 420 and 600 nm. **Version 2 solar data of Volume 33 were scaled upward accordingly; however, Version 0 remain traceable to the original scale of the primary standard F-616.**

Figure 1 shows a comparison of the three working standards and long-term standard 200WN007 based on absolute scans taken on 8/26/2023 and 9/4/2023. Measurements of lamp 200W011 are based on recalibrated data. The scales of spectral irradiance of the five standards agreed to better than ±0.5% on average in the UV-A and visible range, and ±1% in the UV-B range. A similar comparison was performed at the end of the reporting period (on 4/29/24 and 5/12/24) with similar results, confirming that calibrations of the reporting period are consistent within acceptable limits.

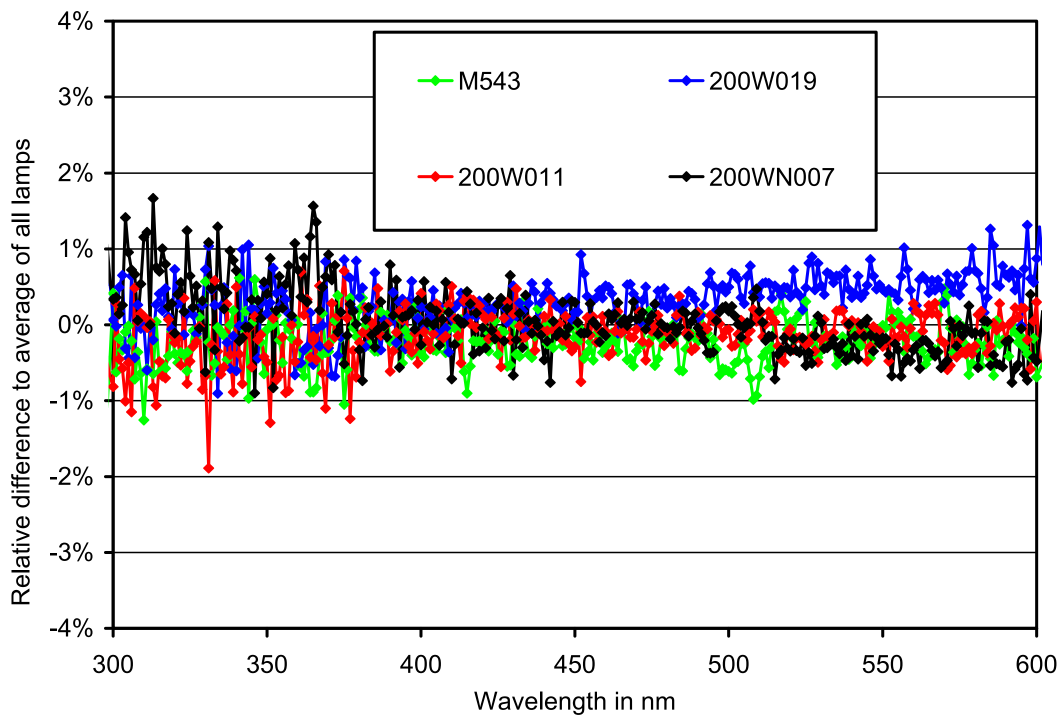

Figure 1. Comparison of all McMurdo working and long-term standard 200WN007 using absolute scans performed on 8/26/2023 and 9/4/2023.

The scale of irradiance maintained by the five on-site standards was further checked by comparing SUV-100 measurements with data of the collocated GUV-511 radiometer. Like in the last years, the GUV radiometer was vicariously calibrated against the SUV's measurements. Calibration factors established for the GUV's 305, 340, and PAR channels for the 2022/23 period agreed to within 0.3% with those calculated for the reporting period, confirming that the scales of spectral irradiance applied to solar data of the SUV-100 spectroradiometer in 2022/23 and 2023/24 are consistent within reasonable limits.

1.2. Instrument Stability

The temporal stability of the SUV-100 spectroradiometer was assessed by (1) analyzing measurements of the internal reference lamp, (2) analyzing absolute scans using the on-site standards, (3) comparing SUV-100 measurements with data of the collocated GUV-511 radiometer, and (4) comparing solar measurements with results of a radiative transfer model. Results of the four methods are reviewed below.

Figure 2 shows results from measurements of the internal lamp. Specifically, readings of the instrument's TSI sensor (a filtered photo diode with sensitivity mostly in the UV-A) are compared with measurements of the SUV-100's PMT at 300 and 400 nm. TSI readings increased by about 1.5% over the reporting period, indicating good stability of the internal lamp. For a perfectly stable system, TSI and PMT measurements would track each other in response to a change in the lamp's output. In actuality, PMT measurements at both wavelengths increased by about 4% between the start of the reporting period and the end of February 2024, and decreased by 2% over the remainder of the reporting period. By "pairing" solar scans with scans of the internal lamp that were performed on the same day as the solar measurements, day-to-day changes of the system's sensitivity (as indicated by changes in PMT current and/or monochromator throughput) are corrected.

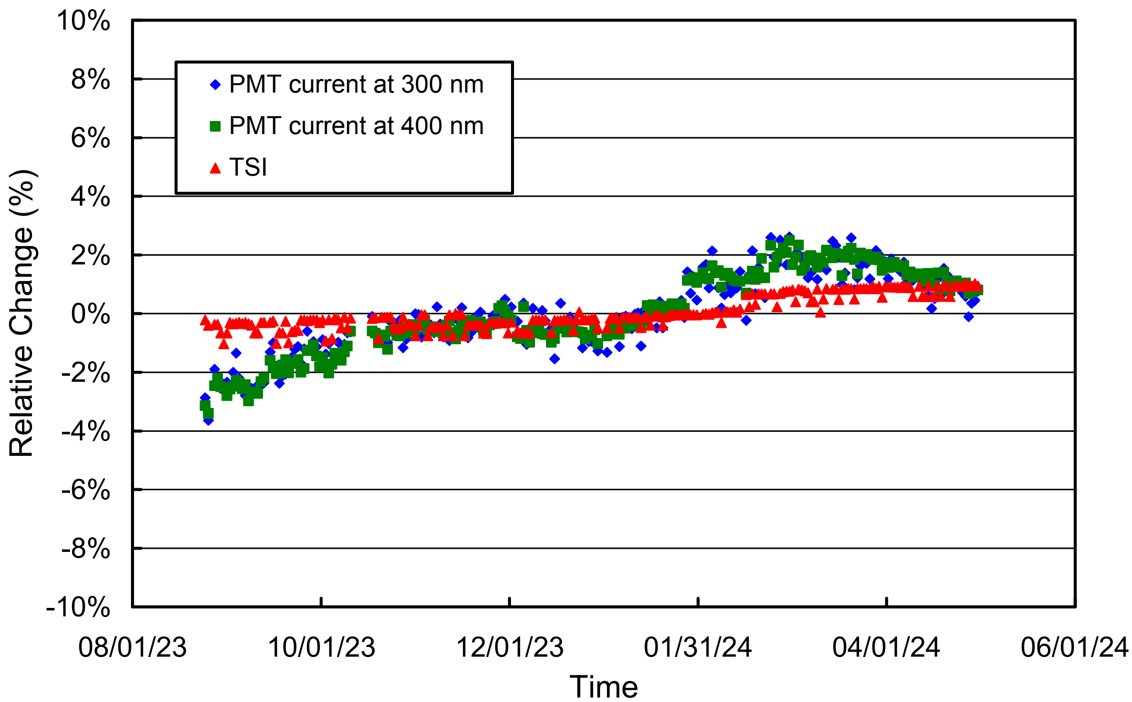

Figure 2. *Measurements of the SUV-100's TSI sensor and PMT currents at 300 and 400 nm. Data are shown as relative change and normalized to the average of the entire period.*

Examination of scans of the on-site standards confirmed that the system was extraordinarily stable during the reporting period. Only one calibration was required for the entire period, which was the average of the results of 28 absolute scans performed throughout this period. In the UV range (290–400 nm) the relative standard deviation calculated from the dispersion of the 28 scans and their average was only 0.7%.

Figure 3 shows the ratio of measurements of the 340 nm channel of the GUV-511 radiometer, which is installed next to the SUV-100 system, and final "Version 0" SUV-100 measurements. The latter measurements were weighted with the spectral response function of the GUV's channel. The ratio is normalized and should ideally be one. The graph indicates that GUV and SUV measurements are consistent to within about ±5% except with the exception of a few outliers, which can partly be attributed to shading from obstacles that are in the field of view of the instruments. Because GUV and SUV radiometers are not positioned at exactly the same location, shadows from these obstacles fall on the collectors of the two instruments at different times. Scans affected by shadowing were flagged in the SUV-100 Version 2 dataset, removed from the GUV dataset, but remain part of the SUV-100 Version 0 dataset.

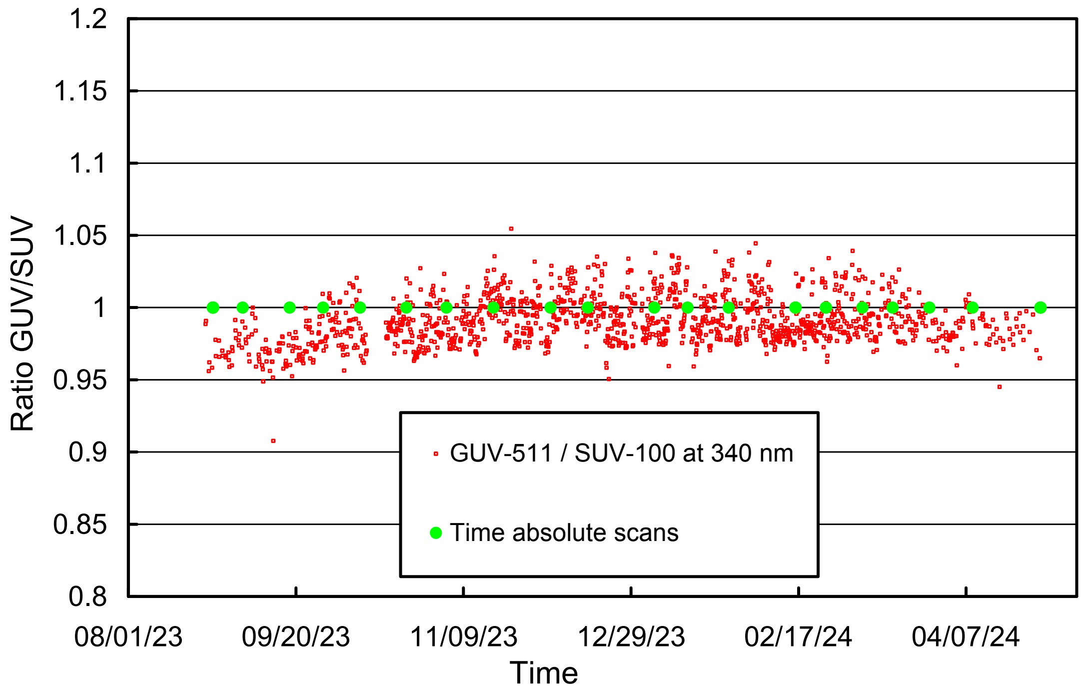

Figure 3. *Ratio of GUV-511 (340 nm channel) and SUV-100 measurements. The times when "absolute" calibration scans of the SUV-100 were performed are indicated by green symbols.*

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. The wavelength-dependent bias of this homogenized dataset and the correct wavelength scale was determined with the Version 2 Fraunhofer-line correlation method (Bernhard et al., 2004). Figure 4 shows the correction function calculated with this algorithm.

Figure 5 indicates the wavelength accuracy of Version 0 data for six wavelengths in the UV and visible range, which was established by running the Fraunhofer-line correlation method for a second time. Shifts are typically smaller than ±0.1 nm, but these residuals are not uniformly distributed over the reporting period. Instead, shifts vary between +0.1 nm and –0.1 nm and have a periodicity of about 14 days. The reason of this periodicity could not be identified.

The wavelength correction was further improved when processing Version 2 data by breaking the dataset into 53 sub-periods with a different correction function applied in each sub-period. Figure 6 shows the residuals of the wavelength offsets for the Version 2 dataset. The improvement of the wavelength accuracy compared to the Version 0 dataset (Figure 5) is obvious. The standard deviation of residuals between 300 and 400 nm is only 0.021 nm.

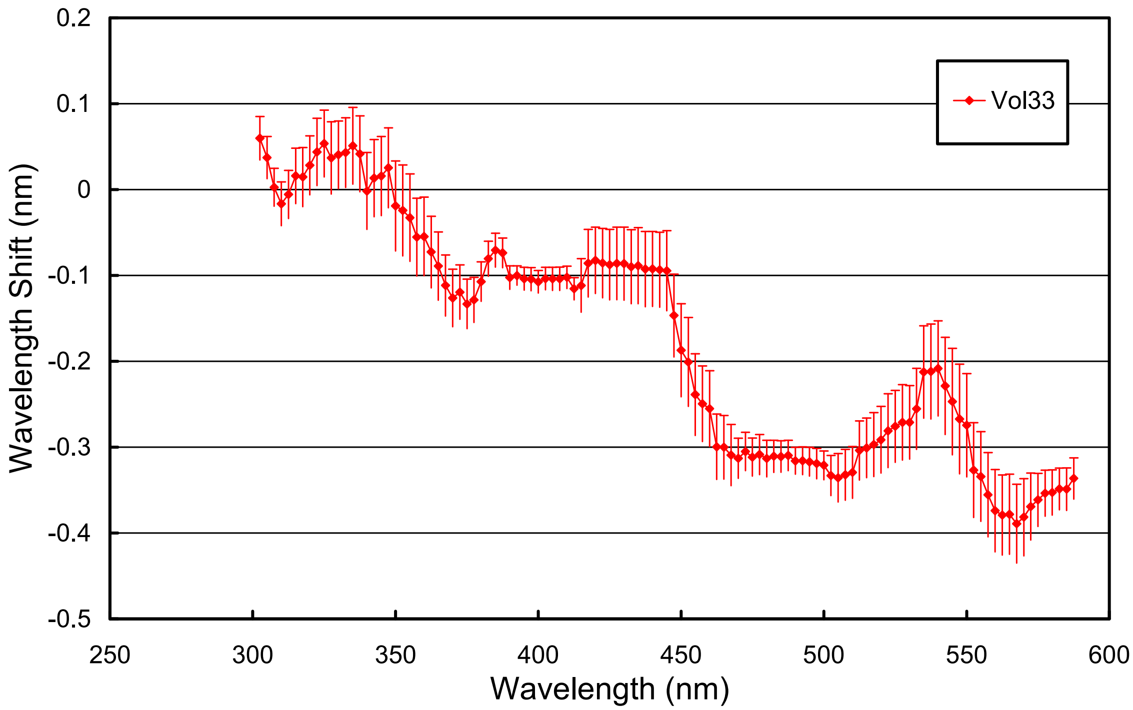

Figure 4. *Monochromator non-linearity correction function for the Volume 33 period. Error bars indicate the 1σ-variation.*

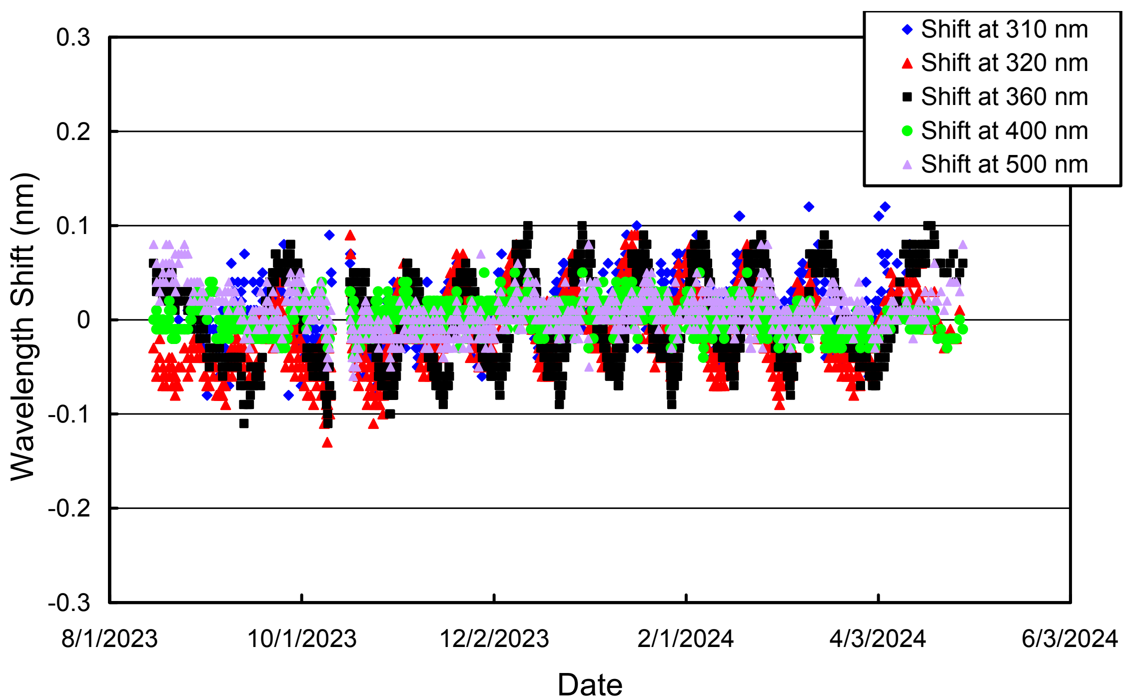

Figure 5. *Check of the wavelength accuracy of Version 0 data at five wavelengths by means of Fraunhofer-line correlation. The plot is based on measurements that are one hour apart.*

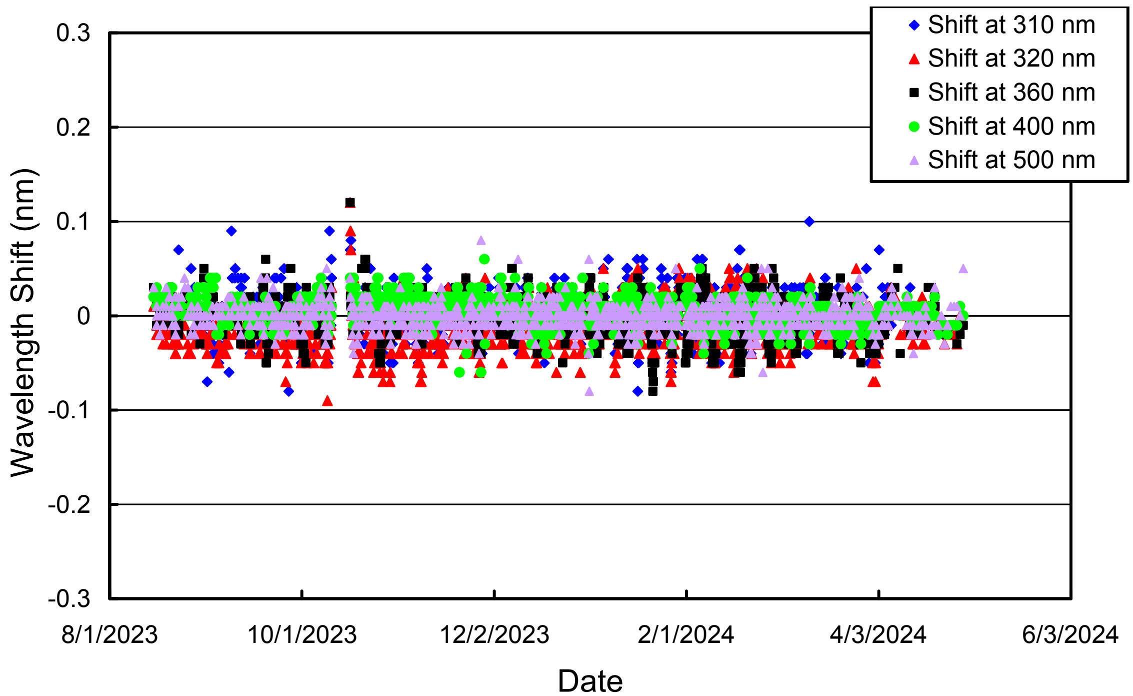

Figure 6. *Check of the wavelength accuracy of Version 2 data at five wavelengths by means of Fraunhofer-line correlation.*

1.4. Missing data

Table 1 provides a list of days that have substantial data gaps, plus indications of their causes.

Table 1: Days with substantial data gaps.

Date	Reason
09/14/23	Unknown
10/11/23 – 10/16/23	Wavelength of monochromator grossly misaligned
12/02/23 – 12/03/23	Testing of new USB-to-serial adapter
12/30/23 – 01/02/24	Problem establishing monochromator’s wavelength setting
01/31/24 – 02/01/24	Problems getting system running again after computer reboot
02/15/24 – 02/16/24	Multiple calibration scans
02/22/24 – 02/23/24	Problem establishing monochromator’s wavelength setting
03/13/24	Unexpected computer reboot
04/10/24	Unknown

References

Bernhard, G., C. R. Booth, and J. C. Ehramjian. (2004). Version 2 data of the National Science Foundation’s Ultraviolet Radiation Monitoring Network: South Pole, *J. Geophys. Res., 109,* D21207, doi:10.1029/2004JD004937.

Bernhard G. and S. Stierle (2020). Trends of UV Radiation in Antarctica, Atmosphere, 11(8), 795, doi: https://doi.org/10.3390/atmos11080795.