Part No. 125.9505

MIDDLETON SOLAR

UVR1 ULTRAVIOLET PYRANOMETER

USER'S GUIDE

UVR1-T2 for UV-Total

UVR1-A2 for UV-A

UVR1-B2 for UV-B

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Middleton Solar, made in Australia

www.middletonsolar.com

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1 GENERAL

The UVR1 Pyranometers are for measuring solar global ultraviolet irradiance on a plane surface. The UVR1-T2 is for UV Total, 280-400nm. The UVR1-A2 is for UVA, 315-400nm. The UVR1-B2 is for UVB, 280-315nm.

2 CONSTRUCTION

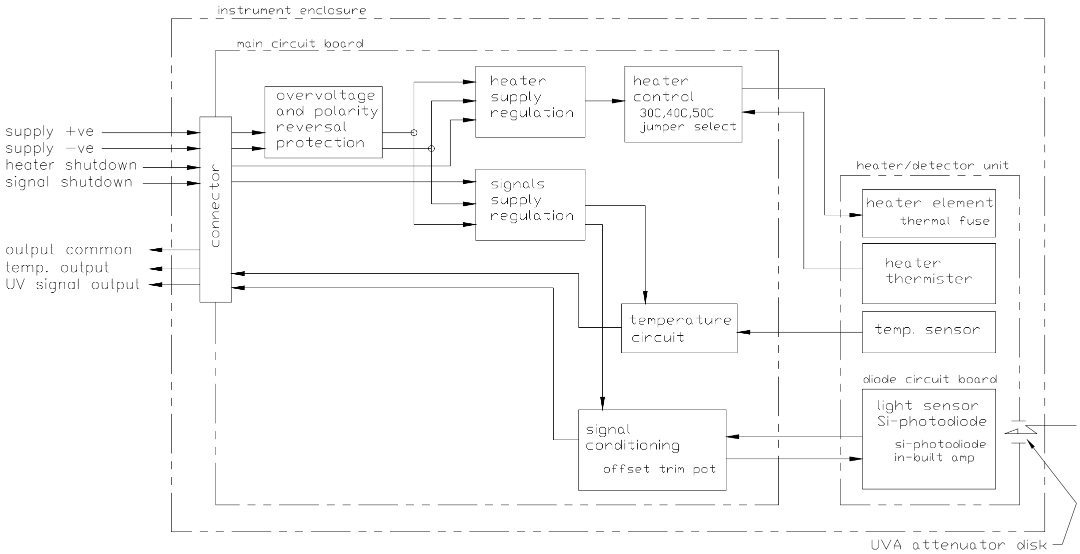
The UVR1 is machined from marine-grade aluminium and is anodised to provide a durable, corrosion-resistant finish. A proprietary cosine-corrected diffuser with integrating cavity gives the UVR1 outstanding directional response.

The detector is a large-area silicon photodiode with an on-chip low-noise amplifier. Light reaches the detector main-filter after passing through a pre-filter that rejects most of the visible spectrum. The main-filter sets the UVT, UVA, or UVB bandpass. This dual filter configuration gives highly efficient rejection of all non UV spectrum. Large diameter filters are used for long-life stable performance, and light passing through the filters is constrained to a narrow angle to avoid distortion of the interference filter bandpass. The main-filter is housed, with the detector, in a temperature controlled heater assembly that is thermally isolated from the instrument body. The heater maintains the detector and filter at a precise temperature to minimise thermal errors.

The heater electronics are completely separate from the detector electronics to avoid heater induced noise on the UV signal. The heater supply current is regulated such that heater performance is not influenced by variation in the supply voltage.

The UVR1 has an additional output for detector temperature. Two shutdown inputs (one for the heater, one for the detector) are provided for low-power standby operation.

Figure 1. UVR1 Functional Block Diagram.



3 INSTALLATION

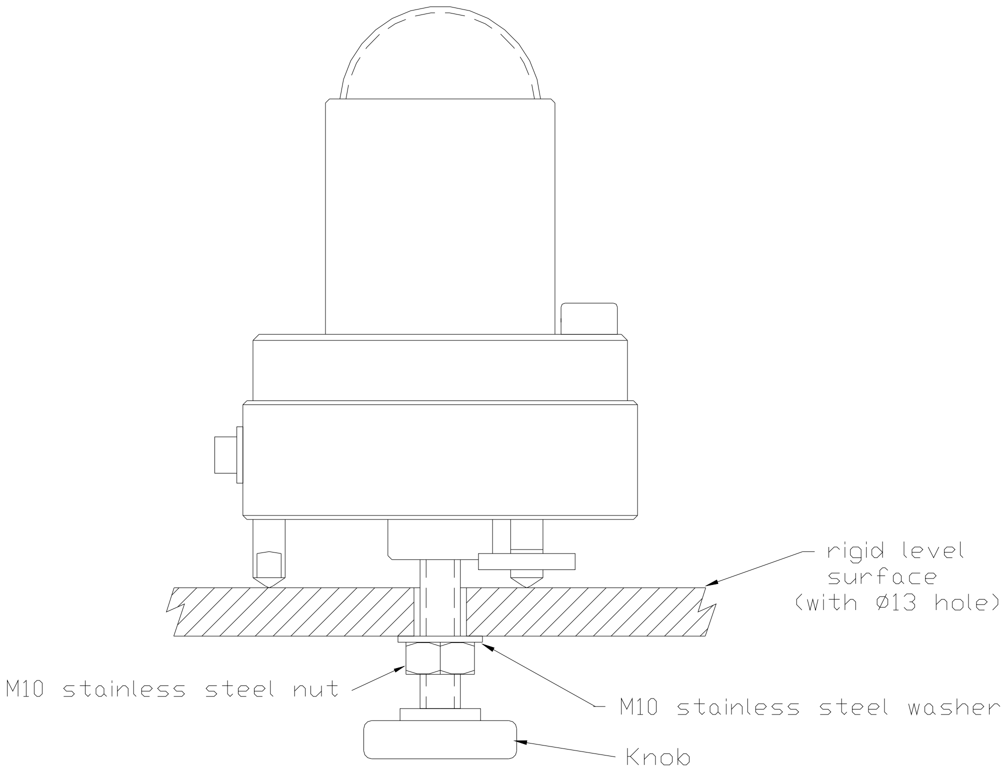
3.1 SITE SELECTION

Select a site where obstructions do not exceed 5 degrees of elevation, in the path followed by the sun, between earliest sunrise and latest sunset during the year.

3.2 MOUNTING

The UVR1 should be mounted on a rigid level surface. The instrument is provided with a central M10 x 1.5p hole in its base. The mounting knob supplied should be screwed into this hole and the instrument mounted as shown in Figure 2, using the washer & nut provided. Once installed the height of the feet can be adjusted until the circular level is centred. Secure the knob & nut finger-tight only (do not over-tighten). Directional errors will result if the instrument is not level.

Figure 2. UVR1 Mounting



Alternatively the UVR1 can be fastened using the two additional mount holes in the base. These holes are M4 x 0.7p, 65mm center to center.

3.3 ELECTRICAL CONNECTION

The power supply requirement is 5.5 to 14.5VDC, 12W peak. The UVR1 can be conveniently powered from any 6V, 9V, or 12V source such as a datalogger, small power supply, or battery. Do not operate the instrument outside the specified voltage range. Allow 30 minutes for the detector to thermally stabilise from a cold start.

The standard heater setting is 40°C, which is suitable for ambient temperatures from -15°C to +35°C. The heater can be set to 30°C for operation in very cold climates, or to 50°C for hot climates. To select alternative settings see Appendix C1. The heater duty cycle is typically on-time = 20% (on-time power requirement is 12W, off-time is <0.5W)[1].

The circuit board has an auto-reset fuse to protect the electronics from damage if the supply polarity is wrongly connected for a brief time.

The UVR1 is supplied with a shielded lead. The shield is floating at the body end of the lead and can be grounded at the measurement end. The cable cores are:

black = power supply negative (for power supply and shutdowns)
red = power supply positive (5.5 to 14.5V, 12W)
violet = heater shutdown to standby (connect to supply +ve to activate)
white = signal shutdown to standby (connect to supply +ve to activate)
brown = output common (ground)
blue = heater temperature output (10mV per ºC. eg: 20ºC is 200mV)
yellow = UV signal output (typically 1 to 3V fullscale in summer)

The measurement equipment should range up to 3V and have an input impedance of at least 1MΩ (see Appendix A for output source impedance).

The temperature output provides assurance that the heater is functioning and that the UV signal is not subject to thermal errors.

Standby operation is useful if the instrument is to be operated in a remote site on battery power. Standby is selected by connecting the white core to supply +ve (for signal shutdown), or connecting both the violet & white cores to supply +ve (for heater & signal shutdown). When both the signal and the heater are shutdown the UVR1 draws less than 1mA. See Appendix D for information on the temperature errors that occur when the heater is not operating.

[1] Duty cycle can be estimated as: on-time(%) = heater(°C) - ambient(°C). eg: 25% on-time if heater is 50°C and ambient is 25°C.

4 MAINTENANCE

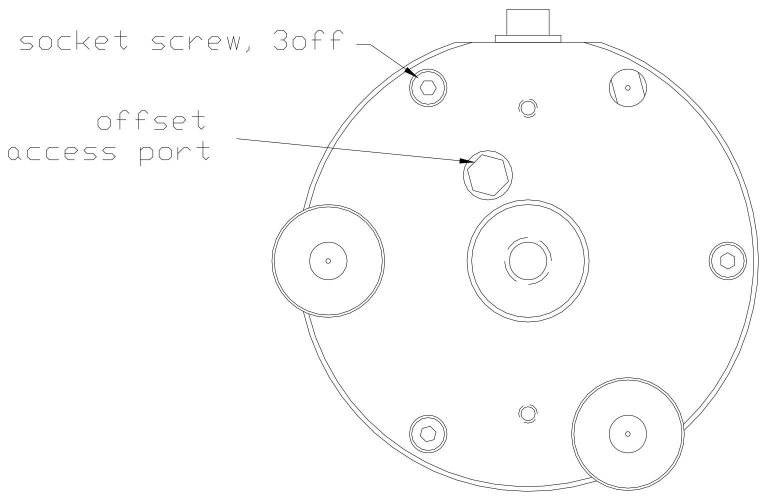
Keep the protective dome clean. Use only water and mild detergent to gently wash the surface.

The instrument contains a desiccant sachet (non-toxic silica gel) to prevent internal condensation and to provide a low humidity environment to prolong the life of the interference filters.

To replace the desiccant use a 3mm hex-key to remove the three socket screws (see Figure 3) and separate the base from the top[2]. Take care not to alter the setting of the potentiometer on the exposed circuit board.

When refitting the base take care to locate the O-ring in its groove before securing the three socket screws; the *Offset* potentiometer (labelled on the circuit board) should be aligned with the access port in the base.

Figure 3. View of Underside of UVR1



[2] A quick alternative method to desiccate the interior is to loosen (but not remove) the three socket screws and purge the interior by forcing dry air through the offset access port.

5 CALIBRATION

Each UVR1 pyranometer is individually calibrated during manufacture and the sensitivity in mV per $W.m^{-2}$ is inscribed on the instrument label. The calibration is valid for the 40ºC heater setting[3]. It is recommended that the calibration be checked annually for an instrument in continuous use.

The UVR1-T2 central wavelength and bandpass has been selected so that the signal represents the integral of UV Total radiation, 280nm to 400nm. Fullscale summer UVT is typically less than 73 $W.m^{-2}$.

The UVR1-A2 central wavelength and bandpass has been selected so that the signal represents the integral of UVA radiation, 315nm to 400nm. Fullscale summer UVA is typically less than 70 $W.m^{-2}$.

The central wavelength and bandpass of the UVR1-B2 has been selected so that the signal represents the integral of UVB radiation, 280nm to 315nm, and so that the calibration can be converted to represent the human erythema action spectrum, or other biological action spectrums (see Appendix G). Fullscale summer UVB is typically less than 3 $W.m^{-2}$.

6. CALCULATION

The output signal can be modified for spectral and cosine response and then converted to units of UV irradiance by application of the calibrated sensitivity.

S = (U * CCF * SCF) / K

where
S = UV irradiance (W.m-2)
U = UV signal voltage (mV)
SCF = Spectral Correction Function
CCF = Cosine Correction Function
K = UV sensitivity (mV/W.m-2)

However for simplicity, the sensitivity (K) is calibrated so that the CCF and the SCF can be neglected for typical measurement conditions, so that

S = U / K

where
S = UV irradiance (W.m-2)
U = UV signal voltage (mV)
K = UV sensitivity (mV/W.m-2)

See Appendix E for information regarding the CCF, and Appendix F for information regarding the SCF.

[3] See Appendix D for information on thermal errors that occur at other heater temperatures.

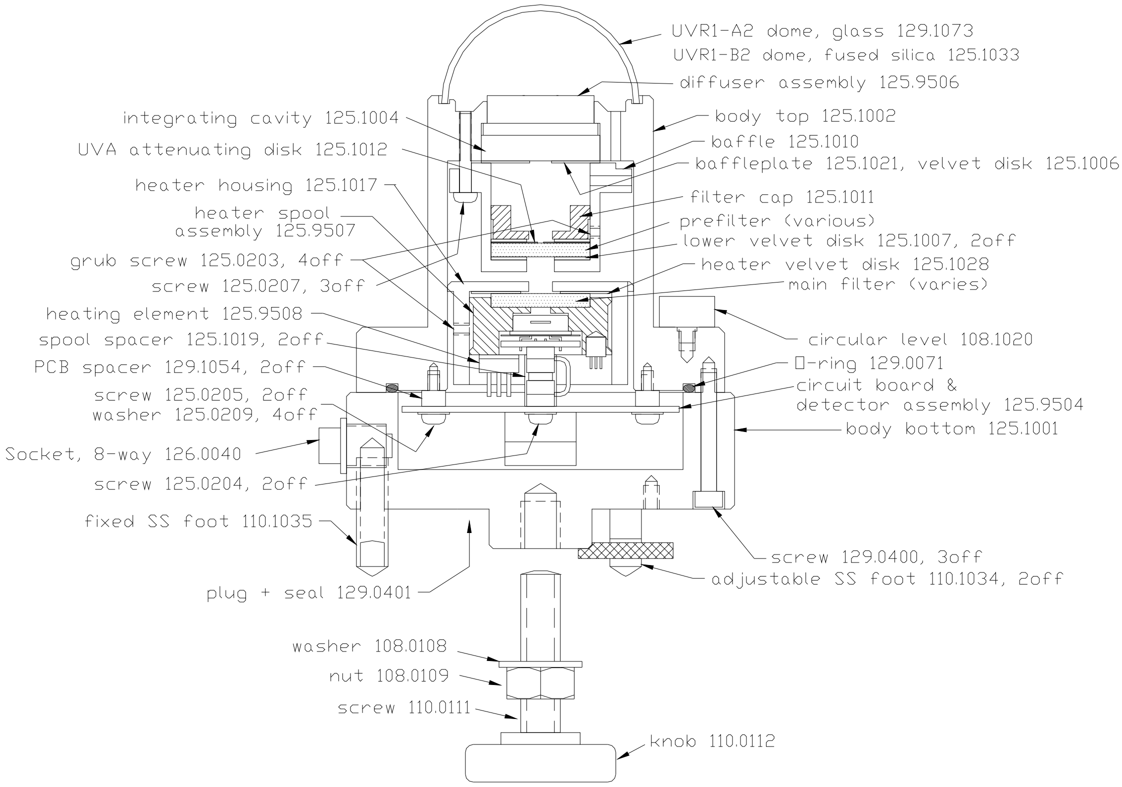
APPENDIX A. Technical Specification

viewing angle	2π steradians
spectral range	UVR1-T2: 280-400nm (UV-Total) UVR1-A2: 315-400nm (UV-A) UVR1-B2: 280-315nm (UV-B)
filter size; slope angle	Ø25 mm; 8° max.
detector type; active area	UV si-photodiode + amp.; 25 mm^2
irradiance: UVR1-T2 UVR1-A2 UVR1-B2	0-95 $W.m^{-2}$ 0-90 $W.m^{-2}$ 0-6 $W.m^{-2}$, 0-10 MED/hr
sensitivity: UVR1-T2 & UVR1-A2	15 - 35 $mV/W.m^{-2}$ (typical)
UVR1-B2	400 - 900 $mV/W.m^{-2}$ (typical)
output (typical full-scale range)	0 - 3V DC (0 – 1V DC option)
resolution	< 0.1% of full-scale
linearity	< 1%
response time (95%)	< 0.5s
long-term stability	< –3% (per year)
directional error (cosine + azimuth)	< 3% (0°- 85° zenith angle)
sideband error: UVR1-T2 & UVR1-A2	negligible
(% signal, typical) UVR1-B2	<3.5% (summer), <9% (winter)
dark offset (for 50°C ambient change)	±1.5mV (30°C & 40°C heater) ±2.5mV (50°C heater)
temperature error	negligible (when heater on)
operating ambient temperature: heater on	-30°C to +45°C
heater off	-20°C to +60°C
thermal control: heater set-point selection (default setting is 40°C)	30°C (for -30°C to +25°C ambient) 40°C (for -15°C to +35°C ambient) 50°C (for -5°C to +45°C ambient)
set-point stability	< 2.5°C (for 50°C ambient change)
duty cycle (% on); frequency	10% to 60%; 0.02Hz to 0.1Hz
warm up rate	5°C/minute
cooling time constant	15 minutes (63%)
power supply requirement (heater on)	5.5 to 14.5VDC, single supply 12W max., 2W typical
standby current draw	heater only shutdown: < 30mA heater + detector shutdown: < 1mA
temperature signal (detector/filter); accuracy	10mV/°C (eg: 0.4V = 40°C); ± 1°C
measurement instrument requirement	-0.05 to +2.0VDC, > 1MΩ
output source impedance: UV signal	220Ω
temperature	1KΩ
dome	glass or fused silica
bubble level resolution	0.2°
desiccant	non-toxic silica gel
lead	6m; connector at instrument end

APPENDIX B. Spare Parts

Spare parts may be ordered from the manufacturer or through an approved distributor. The part names and corresponding numbers are shown in Figure A. Please quote both when ordering. It is also important when ordering parts to include the Model Type (UVR1-T2, UVR1-A2, UVR1-B2) and Serial Number. This information is inscribed on the identification label. Contact the manufacturer for technical repair information.

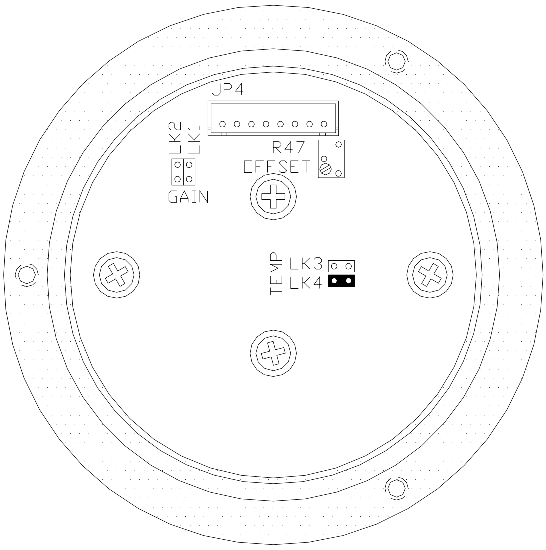
Figure A. UVR1 Spare Parts



note: parts 125.1011, 125.0013, 125.1007 not used in all instruments

APPENDIX C. Circuit Board Settings

Figure C. View of UVR1 with Base Removed
(set for 40°C heater)



C1) To Change Heater Setting (see Figure C)

Access the circuit board by separating the base from the top as described in Section 4. See Appendix A for ambient temperature range for each heater setting. The heater temperature is set with link-plugs fitted to LK3 and LK4:

- 30°C = no link-plugs fitted
- 40°C = link-plug fitted to LK4 only (standard setting)
- 50°C = link-plug fitted to LK3 only

The heating element has a thermal fuse to protect the detector & main filter if the control fails to full-on.

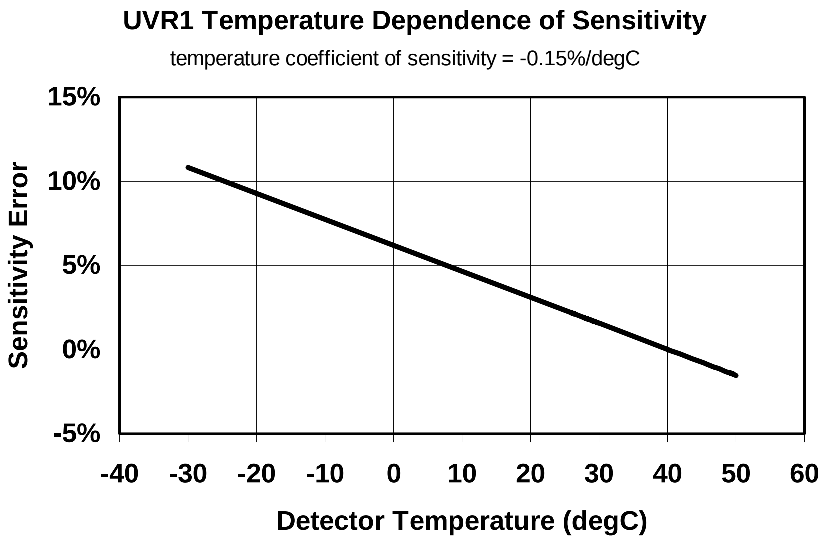
C2) UV Signal Gain Setting (see Figure C)

The gain is set during manufacture. LK1 and LK2 may (or may not) have link-plugs fitted. Do not alter the factory setting.

APPENDIX D. Temperature Response

D1) Temperature Dependence of the Sensitivity

A temperature dependent sensitivity error will occur if the UVR1 is operated with the heater off. The typical temperature response of the sensitivity is illustrated in the chart below (error is zero at 40°C, the standard heater setting). The sensitivity variation is caused by a combination of change in the light absorption characteristic of the detector and expansion/contraction of the main interference filter[4].



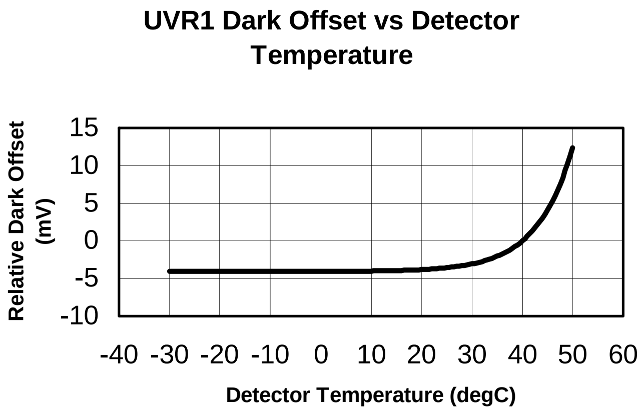
If a typical UVR1-B2 instrument having a calibrated sensitivity of 350 $mV/W.m^{-2}$ (at 40°C heater setting) is operated at 7°C, with the heater shutdown, then its actual sensitivity will be 5% greater (viz: 368 $mV/W.m^{-2}$). The error coefficient can be determined for a specific instrument by logging the detector temperature output and the UV signal, against a reference instrument UV signal, over the desired temperature range, and subtracting the (temperature dependent) dark offset from the results.

D2) Temperature Dependence of the Dark Offset

A temperature dependent dark offset will occur if the UVR1 is operated with the heater off. The typical temperature coefficient of the dark offset is 1.15 times/°C, as illustrated in the chart below[5]. The dark offset variation is caused by increasing excitation of electrons in the detector as the temperature rises.

The error coefficient can be determined for a specific instrument by logging the detector temperature output, along with the UV dark signal, over the desired temperature range.

[4] The main interference filter has a temperature coefficient of 0.016nm/°C.
[5] eg: if the dark offset at 30°C is 1mV, then at 40°C it will be 1x1.15^(40-30)=4mV



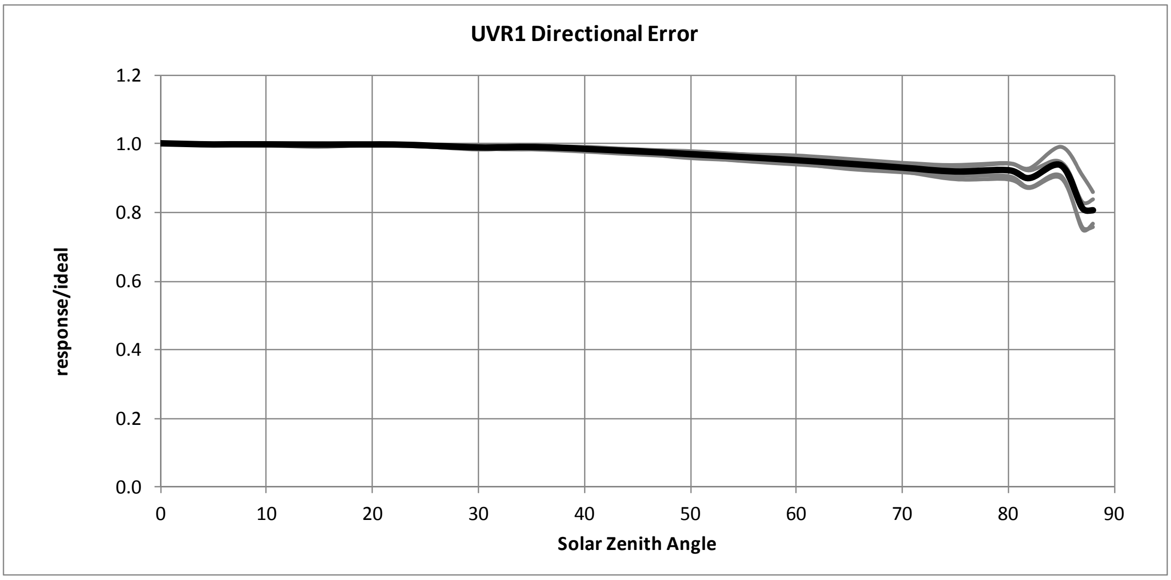
The relative dark offset is factory adjusted to be zero for a 40°C heater setting. If the Heater is set to 30°C or 50°C the dark offset will have to be re-adjusted as described below[6].

To adjust the dark offset:

- select the desired heater temperature (see Appendix C1)
- cover the dome with aluminium foil (or other opaque material)
- power up the instrument and wait until the detector temperature has stabilised (approx 30 minutes)
- remove the plug+seal, using a 7mm AF socket wrench, from the offset access port (see Figure 3)
- use a small screwdriver to adjust the offset trimpot through the port
- replace the plug+seal, and remove the aluminium foil

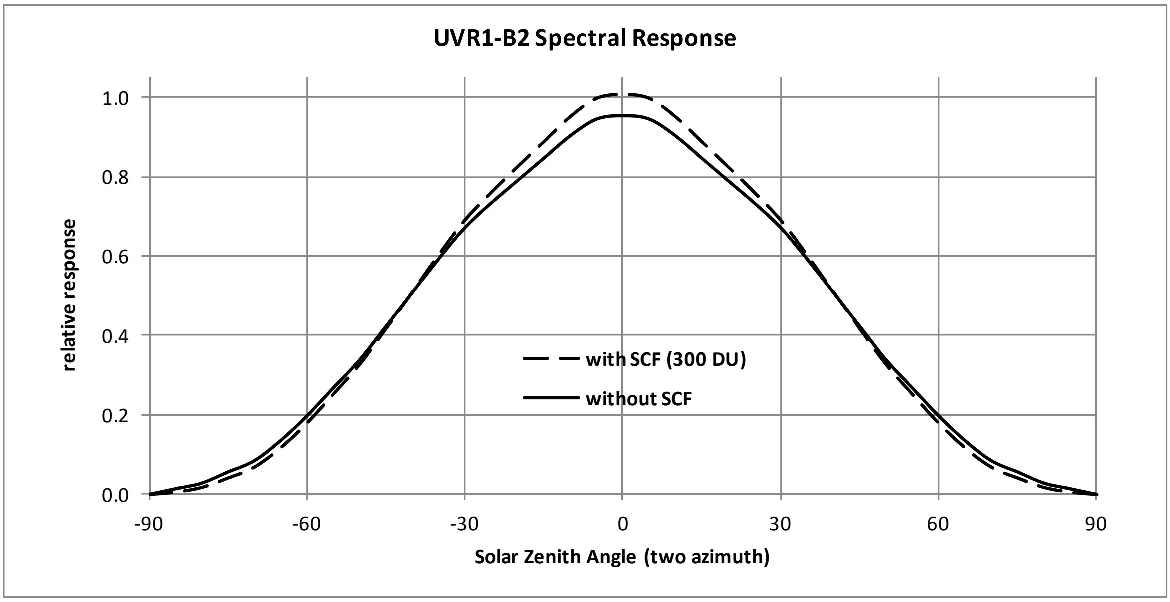
[6] zero dark offset may not be achievable for the 50°C heater setting

APPENDIX E. Directional Response & CCF



The UVR1 has a proprietary cosine-corrected diffuser (with integrating cavity) to give optimal directional response, especially at low sun elevation angles. The cosine response is nearly the same for all azimuth directions. The chart above shows the directional response of a typical UVR1, in four azimuth orientations (North, South, East, and West). A weighted Cosine Correction Function (CCF) is incorporated in the calibrated sensitivity of each instrument.

APPENDIX F. Spectral Response & SCF



Typical measurement conditions are 30° to 60° Solar Zenith Angle, and 280 to 320 Dobson Units. A Spectral Correction Function (SCF) accounts for the mismatch of sensor response to defined UV weighting. The UVR1 calibrated sensitivity is set so that, for typical conditions, the response without application of a SCF is comparable to the response if a SCF was applied.

APPENDIX G. UV Index and Minimum Erythemal Dose

UV Index

The Global Solar UV Index (UVI) is defined by the World Health Organisation. An accurate calculation of UVI requires measurement of UV intensity, in W/m2/nm, from 250nm to 400nm. The UV intensity is modified by a wavelength dependent erythemal (sunburn) weighting function, defined by ISO17166. The integral, of the erythemal modified UV (called UVE), is multiplied by 40 to yield the UVI.

However, the erythemal weighting function is negligible for UV above 315nm, so in pragmatic terms the UVI is largely determined by the UVB intensity.

The response of the Middleton Solar UVR1-B2 Ultraviolet Pyranometer represents the integral of solar terrestrial UVB irradiance, on a horizontal surface, in the spectral bandwidth 280nm to 315nm. The response is expressed in W/m2.

The ISO17166 erythemal weighting function, when applied to the UVR1-B2, yields a UVE intensity that is 0.13 x UVB.

Thus, the estimated UV Index can be expressed as:

UVI = 40 x UVB x 0.13

or,

estimated UVI = 5.2 x UVB

For example, if the mid-summer UVB intensity is 2.3 W/m2, then

UVI = 5.2 x 2.3
= 12

A UVI of 12 is considered to be in the extreme category.

Minimum Erythemal Dose (MED)

Erythemal is skin sunburn redness caused by exposure to solar UV radiation.

MED/hour is the dose rate and it is related to the UV Index such that

MED/hr = 0.43 x UVI

or

MED/hr = 2.24 x UVB