Sunshine recorders – an overview

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This note is based upon the author's short article in the *Climatological Observer's Link Bulletin*, January 2012, pp 25-27.

For more information see *The Weather Observer's Handbook* by Stephen Burt (Cambridge University Press, 2012) – Chapter 11, 'Measuring sunshine and solar radiation'.

I would like to measure sunshine duration. I have a Davis Instruments Vantage Pro2 AWS: is it possible to measure sunshine accurately using the optional solar radiation sensor for the Davis, or is it best to use a dedicated standalone sensor? If so, which gives the best results?

It is possible to derive a very approximate measure of sunshine duration by applying a threshold approach to global solar radiation records obtained from pyranometers, such as the optional Davis Instruments sensor for the Vantage Pro2 AWS, the threshold itself usually being a function of solar angle and azimuth. A number of methods have been described (and in The Netherlands such a method has used in place of actual sunshine measurements since 1992), but while some can provide reasonable agreement with monthly and annual totals of sunshine derived from a dedicated sunshine sensor, daily and hourly totals often bear little resemblance to conventional measurements.

Adding solar radiation sensors to a Davis Instruments Vantage Pro2 AWS will provide interesting and useful readings (and monthly means and extremes have been published in COL's monthly bulletin since 2006), but it is important to be aware that the method used by Davis software to estimate 'sunshine' from this *global* sensor does **not** use a variable threshold method based upon solar angle, but instead a fixed threshold of 100 W/m^2. Unfortunately this bears little resemblance to the WMO definition of sunshine, which is 'the duration of the period for which the *direct* solar irradiance exceeds 120 W/m^2'. Although the two use the same units, the quantities measured are very different.

Direct solar radiation is measured from a small area around the solar disk and perpendicular to the incoming beam using a sensitive narrow-aperture sensor known as a pyrheliometer, whereas *global* solar radiation is the all-sky solar radiation incident on a horizontal surface, measured by a pyranometer. The latter usually exceeds 100 W/m^2 near local noon in mid-latitudes in most months of the year, even under cloudy skies. A simple tally of the duration of *global* solar radiation exceeding 100 W/m^2 gives a huge over-estimate of the true duration of sunshine, as shown in **Table 1**, based upon my own measurements in central southern England for 2011.

TABLE 1 Comparison of monthly sunshine duration (measured using an Instromet sensor) and the duration of global solar radiation > 100 W/m² (using a Kipp & Zonen CMP3 pyranometer), both instruments logged every minute by a Campbell Scientific datalogger. Records from the author's observatory site in central southern England, 2011; values in hours

Month	**A** Sunshine total (Instromet) *hours*	**B** Duration global solar radiation > 100 W/m^2 *hours*	**B as % A**
January	47.2	68.5	145
February	47.0	90.2	192
March	141.0	234.5	166
April	233.4	287.2	123
May	212.9	350.3	165
June	175.9	345.3	196
July	158.9	346.5	218
August	145.9	299.3	205
September	156.4	254.6	163
October	151.9	208.3	137
November	65.4	89.3	137
December	76.3	72.8	95
Year 2011	**1611.9**	**2646.8**	**164**

If measurements of sunshine are sought – and to my mind it is one of the most useful and interesting of measurements, and easy enough to do provided you have a reasonably open site – it is best to use a dedicated sunshine sensor. The following table outlines the pros, cons and prices (at early 2012) of a selection of commonly-available instruments.

How do they compare? A comparison of the Campbell-Stokes and Kipp and Zonen sensor was published in *Weather* in 2004 ('Comparison of sunshine recorded by Campbell-Stokes and automatic sensors' by Andrew Kerr and Richard Tabony**,** *Weather*, **59**, pp.90–95: see also Prior, John (2006) Sunshine measurement. *Weather*, **61**, p 77.) A 12 month comparison between the Campbell-Stokes and the Instromet sensor (then known as the R&D sunshine sensor) was published in *Weather* in 1997 ('Trialling of an inexpensive electronic sunshine sensor, June 1995 to May 1996' by C G Roberts, *Weather*, **52**, pp 371-377, December 1997). An extended three-site comparison between Instromet, Kipp & Zonen and Campbell-Stokes sensors is currently under way under the auspices of the Chilterns Observatory Trust and with involvement from the Met Office, and the results will be published in 2013.

What about exposure? Sunshine sensors need an open exposure, at least between north-east and south-east and south-west and north-west. Unobstructed sites are very hard to come by, but provided the horizon is not too cluttered, reasonable records can often be obtained from rooftop sites. The smaller electronic sensors are easier to mount on a rooftop or mast than the larger units such as the Campbell-Stokes which require daily access, 365 days per year, to change the recorder card. Note that safety of access to the instrument is paramount, and **on no account should sensors be exposed in locations which are difficult or dangerous to reach**. The degree of obstruction can be assessed using a solar elevation diagram – details are given in *The Weather Observer's Handbook,* pp 260-265.

Instrument	**Campbell-Stokes sunshine recorder** (Figure 1)
How it works	A spherical glass lens burns a trace in a specially-shaped card in sunshine
Pros	Long-established (developed in 1870s) Standard method for many years, now being superseded by electronic sensors
Cons	Burn threshold very variable Measurement of burn length very subjective (± 15%) Manual instrument – no logger output Cards must be changed daily Needs an open site which is safely accessible on daily basis Cards are expensive (about £80/year)
Prices	New £850 to £1000 or so *Loan units are available from the Chilterns Observatory Trust*
Running costs	About £80/year for cards
Suppliers	Fairmount Instruments www.fairmountweather.com Russell Scientific Instruments www.russell-scientific.co.uk

Instrument	**Kipp & Zonen sunshine recorder** (Figure 2)
How it works	Comparison of three photosensitive detectors, at least one of which is in shade and another fully exposed to the sky. Sunshine results in a differential voltage, which triggers an output signal
Pros	Consistent, calibrated threshold Electrical output, ideal for datalogger records No manual inputs required, little maintenance required after installation Can be sited on rooftop or mast Very fast response time (< 1 ms), can measure just a second or two of sunshine UK Met Office, Met Éireann and German state weather service standard instrument
Cons	Extremely expensive Requires datalogger Calibration may not be accurate even with new instruments – calibration drift (and thus sunshine threshold) may be a problem
Prices	Campbell Scientific current list price £1784+VAT
Running costs	Negligible – requires 12 v supply via mains, battery or solar power, and occasional replacement of desiccator pack
Suppliers	Campbell Scientific www.campbellsci.co.uk Equinox Instruments www.equinoxinstruments.co.uk

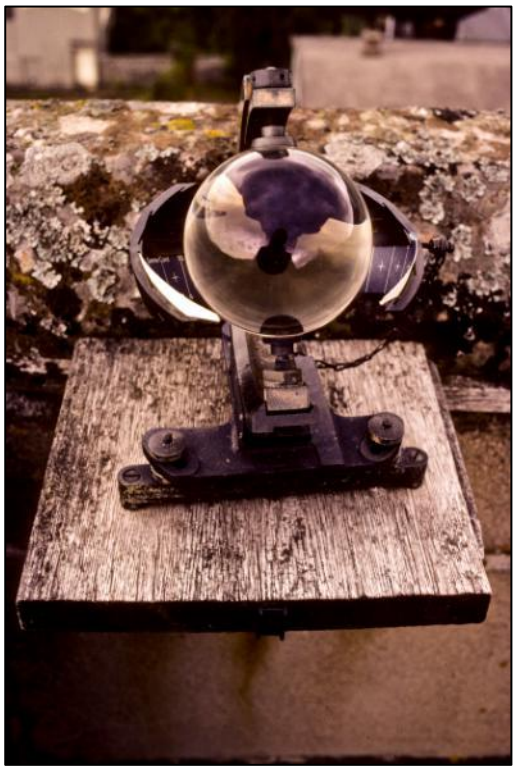
Instrument	**Instromet sunshine recorder** (Figure 3) *(Instromet used to be known as R&D Electronics, and the instruments are still sometimes referred to as 'R&D' sunshine sensors)*
How it works	Comparison of several photosensitive detectors. A small post casts a shadow when the Sun is shining, resulting in a differential voltage which triggers an output signal or a timer increment
Pros	Simple, reliable and easy to install Reasonably priced Standalone display as standard Electrical output easily interfaced to suitable datalogger * No manual inputs required, little maintenance required after installation Small and light – easily sited on rooftop or mast, 25 m cable supplied Fast response time (~ 1 s), can measure just a second or two of sunshine

Cons	Vague calibration – threshold corresponds to bright sunshine rather than a defined radiation intensity level, although can be adjusted given suitable reference sensor Misting-up inside the dome can occur, altering threshold levels Variation between units can be significant, even when exposed side-by-side
Prices	About £270 including VAT
Running costs	Negligible – requires 12 v supply via mains transformer
Suppliers	Instromet www.instromet.co.uk

** A short PDF describing how to do this can be found on www.measuringtheweather.com*

Instrument	**Blake-Larsen sunshine recorder** (Figure 4)
How it works	A sensitive photocell measures full-sky solar radiation using a hemispherical mirror. Sensor output is compared with calculated threshold value to determine 'sunshine/no sunshine'
Pros	Reasonably priced Clean PC software interface, runs on low-power PCs No manual inputs required, little maintenance required after installation Small and light – easily sited on rooftop or mast Fast response time (~ 1 s), can measure just a second or two of sunshine Threshold algorithm can pick up sunshine down to the horizon
Cons	Still under development – software not yet stable/reliable Not 'standalone' - requires connection to host PC for threshold calculation and logging Limited integration with PC AWS software packages (yet) No datalogger output option (yet) Very new sensor – few comparisons yet available with other devices to assess performance
Prices	About €400 including VAT
Running costs	Powered from PC USB supply
Suppliers	www.sunrecorder.net

- *Figure 1 – Campbell-Stokes sunshine recorder*



< Figure 2 – Kipp & Zonen CSD sunshine recorder

- *Figure 3 – Instromet sunshine recorder*

< Figure 4 – Blake-Larsen sunshine recorder