Evaluation of the Delta-T SPN1 as a sunshine meter.

Dr. Nicole Hyett
The SPN1
Why measure sunshine?

- Measure of climatology of a place, particularly cloudiness.
- Agriculture
- Tourism
- Health
- Solar power
- Can be used as an estimate of global solar radiation
WMO specifications for sunshine duration

The sum of the time for which the direct solar irradiance exceeds 120 W m\(^{-2}\).

Daily totals of sunshine should be measured with an

• uncertainty of ± 0.1 h day\(^{-1}\) and a

• resolution of 0.1 h.

0.1 h = 360 s

Experimental procedure

- Compare results from SPN1 to reference (CH1)
- Instruments co-located at Adelaide Airport
- 1s sampling
- Experiment ran for 182 days (2-Oct-2015 to 31-Mar-2016)
Location of experiment
The CH1
Calibration of instruments

**SPN1-A124**
- Calibrated June 2014
- Factory calibration
- Error after recalibration: 0.1%
- Accuracy = ± 10 %
- Recalibration recommended every 2 years

**CH1-070592**
- Calibrated Nov 2013 & Oct 2015*
- BoM calibration
- Traceable to WRR
- Uncertainty after calibration < 1.5%
- Recalibration recommend every year (but we do two-yearly)
Sunshine statistics for Adelaide Airport

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Jan</th>
<th>Feb</th>
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<tbody>
<tr>
<td>Mean daily sunshine (hours)</td>
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<tr>
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# Sunshine statistics for Adelaide Airport

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A "typical" day

Source: BoM Ground Based Networks
A much more typical day

Mean Irradiances Adelaide 10/2/2016

Source: BoM Ground Based Networks
A typical day from a sunshine point of view

2016-3-15

No. of Seconds

Time

06:00:00 08:00:00 10:00:00 12:00:00 14:00:00 16:00:00 18:00:00

SPN1
CH1
A typical day from a sunshine point of view
A typical day from a sunshine point of view
Data selection

- Data from CH1 undergoes manual QA & removal of "bad" data.
- Each day must have > 99% of data from SPN1
- Removed any days that had major tracking issues.
- Removed any minutes that were missing even a single second.
- We are left with 163 days and 2121 hours of data.
Sunshine Duration (Hours) vs Date

Daily Totals

Sunshine Duration (hours)

Date

CH1
SPN1

Daily totals including the Campbell Stokes sunshine recorder
Plot of CH1 vs SPN1

\[ y = 0.99 \times + 0.03 \]
\[ R^2 = 0.998 \]
Does the difference change with time?
Does the difference change with time?

![Difference vs Time](chart.png)
Difference vs Sunshine Duration

[Scatter plot showing the relationship between Difference (SPN1-CH1) and Sunshine Duration (hours/day). The plot includes a range of data points scattered across the graph, with a trend indicating a positive correlation.]
Histogram of differences
Histogram of differences
The contribution of elevation to the uncertainty
The contribution of irradiance to the uncertainty
Difference vs Irradiance
(low elevations shown separately)
Difference with low elevation removed
Does the SPN1 meet the requirements?

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<th>Uncertainty</th>
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<th>% of days</th>
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<tr>
<td>All elevations</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>120 Wm(^{-2})</td>
<td>± 0.1 h</td>
<td>81</td>
<td>50%</td>
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<td>120 Wm(^{-2})</td>
<td>± 0.3 h</td>
<td>155</td>
<td>95%</td>
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<tr>
<td>Elevations &gt; 6</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>120 Wm(^{-2})</td>
<td>± 0.1 h</td>
<td>105</td>
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<td>120 Wm(^{-2})</td>
<td>±0.28 h</td>
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Conclusions

- While the SPN1 does a reasonable job of estimating sunshine duration, it does not meet the WMO standard.
- The SPN1 behaves most poorly at low elevation.
References

User Manual for the Sunshine Pyranometer type SPN1
   Delta –T Devices Ltd
   John Wood, 3.0 October 2013

Investigation of the accuracy of the Delta-T Devices BF3 Sunshine Sensor
   Instrument Test Report 700
   Paul Dyson, July 2005

Guide to Meteorological Instruments and Methods of Observation,
   Secretariat of the World Meteorological Organization, Geneva, Switzerland, WMO doc
   Eighth edition, 2014

Solar irradiances measured using SPN1 radiometers: uncertainties and clues for development
   Atmos. Meas. Tech., 7, 4267–4283,
   Jordi Badosa et. al., 2014
Does the SPN1 meet the requirements? (including other thresholds, all elevations)

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<td>96 Wm(^{-2})</td>
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<td>59</td>
<td>36%</td>
</tr>
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<td>120 Wm(^{-2})</td>
<td>± 0.1 h</td>
<td>81</td>
<td>50%</td>
</tr>
<tr>
<td>144 Wm(^{-2})</td>
<td>± 0.1 h</td>
<td>66</td>
<td>40%</td>
</tr>
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