Reviving a vintage Haenni Solar sunshine duration sensor at meteoLCD, Diekirch, Luxembourg.

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09 April 2020 version 1.0a
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Foreword

This is not a scientific paper, but a short story on bringing a vintage Haenni Solar sunshine duration sensor back to function. I added some remarks on the problems to measure sunshine duration, but the aim of this paper is to document and entertain, not to relate the results of scientific research.

1. The Haenni Solar 111 sunshine sensors

Many years ago (in 2007) meteoLCD received as a donation 3 disused Haenni Solar 111 sunshine duration sensors; actually two are of type 111B with MIL connector, and one is type 111 with a Fisher connector. These instruments were in use at Luxembourg weather stations managed by ASTA (Administration des Services Techniques de l'Agriculture) and had been removed, probably for reasons of age or functioning.
The following picture shows the serial #3194 of one of the type 111B sensors; from literature it is known that #3172 was installed in Austria in the TAWES net in 1992, so this might be the age of the shown model.

Fig.1 Serial plate of a 111B type sensor (with MIL connector)

The many-wire cables were simply clipped off, and we graciously received the material without any technical information at all.

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Last year I began thinking to reinstall one of these sensors on our terrace of meteoLCD, simply to give a demonstration of what a working vintage sensor looked alike. The next picture shows the Haenni Solar 111 mounted on the handrail of the terrace (September 2019). The inclination angle is that of the latitude (50° North) and the sensors points straight North. A single multi-wire cable (8 wires) transports the electrical current for heating, powering the internal electronics and motor and sending back the sunshine signal.

Fig.1. The Haenni Solar 111 mounted at meteoLCD

2. The problem of measuring sunshine

One could naively think that measuring when the sun shines and when it does not is an easy, not demanding task; this absolutely is not the case. The classical

sensor used before weather stations became electronic and automatic, was the Campbell-Stokes glass sphere; this transparent sphere of 4 inch diameter works as a lens and burns, when the intensity of the solar irradiance is sufficient, marks into a paper strip. This strip is positioned on the metallic arc seen in the picture and has hourly grid-lines (1 hour corresponds to 2 cm paper length, the width of the burned trace is 2 mm). Simply adding the different burn lengths gives the daily sunshine hours. You might read my paper from 2011 given in **[ref.1]** were the different methods are described in more detail.
This classic instrument is sensitive to ambient humidity and as a general rule trends to "overburning" especially in the summer months, i.e. it gives a yearly total that may be considerably too high (for instance 1800 hours instead of 1700 hours). For an automatically working electronic weather station the CS sensor is a no-go. Replacing it was not easy in the past, and still is not.

Fig.3. The classic Campbell-Stokes glass sphere

Today the sunshine duration is either computed from the measurements of the solar irradiance by a standard pyranometer (see the reference section of ref.1 for some papers on these methods), or one of the few available specialized (and expensive) electronic devices.

We at meteoLCD use a method developed by a Jean Oliviéri, a French scientist of Météo France who worked at the (now defunct) Centre de Radiométrie at Carpentras, France. Jean Oliviéri is now in retirement **[ref.2]**

The specialized electronic instruments mostly work by measuring a difference between diffuse and direct or global irradiance. The WMO has defined that a direct irradiance (i.e. the sensor points to the sun) of 120W/m^2 or higher is the threshold to use for deciding if the sun shines or not. Usually one measurement per minute is made, sometimes even much more.

The next picture shows the Kip& Zonen CSD3 sensor, which has no moving parts, but works with the contrast between shaded and un-shaded photo-diodes:

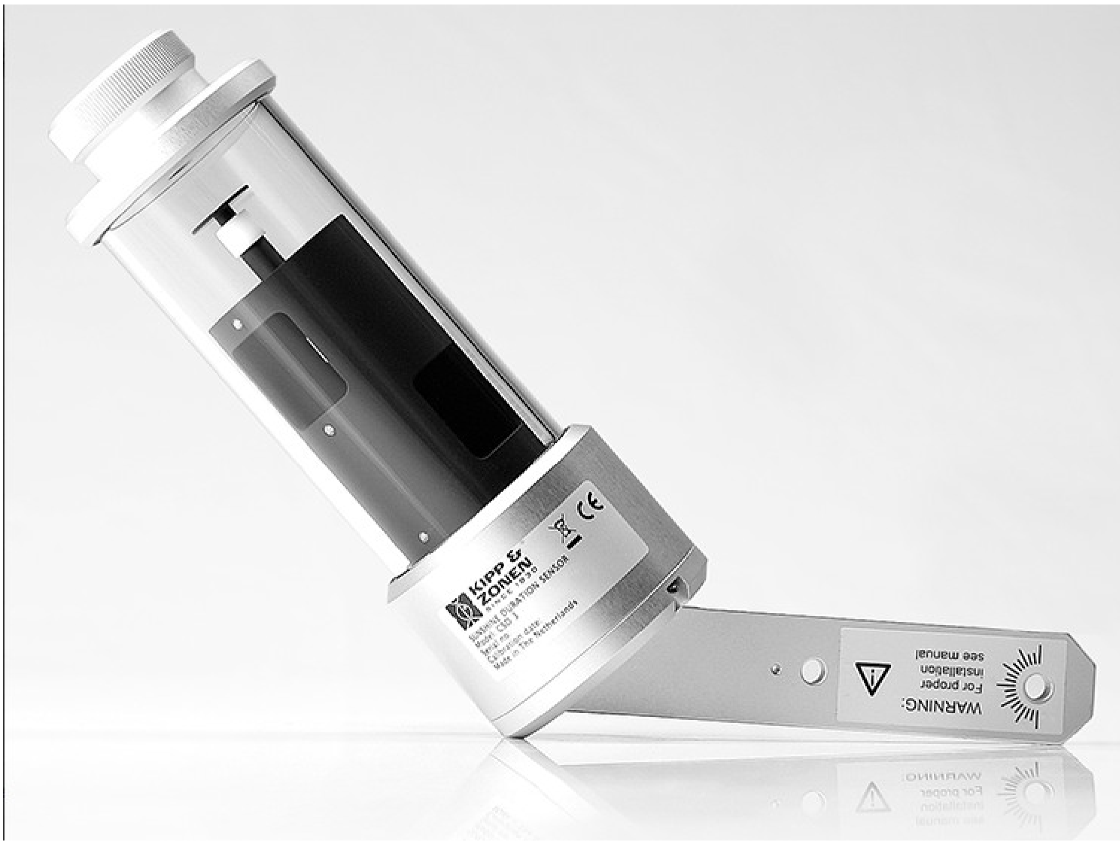

Fig. 4. The Kip & Zonen CSD3 electronic sunshine detector

Delta_T, a UK company specialized in meteorological sensors sells since many year a BF5 sensor which is simply mounted horizontally, and where a patented structure of the shaders is used. This instrument also has no moving parts (see next figure). All these sensors are very expensive, the prices reaching into multiples of thousand Euro.

Many papers compare the different sensors, and find more or less important problems with all of them. As an example, it is not uncommon to find differences in the **daily** sunshine duration of up to two hours **[ref.3, 4]** !

Fig. 5. The Delta_T Devices BF5 sensor

3. Method of operation of the Haenni Solar 111

In contrast to the 2 examples shown above, the Haenni Solar instrument works with a rotating shader (12 rev/sec) which alternatively shades or un-shades a ring of 6 photo-diodes (or thermo-elements, I am not sure about this) mounted around the axis of rotation. The shaded sensor measure the global diffuse irradiance, the un-shaded the global irradiance.

The next figure shows the dismounted sensor:

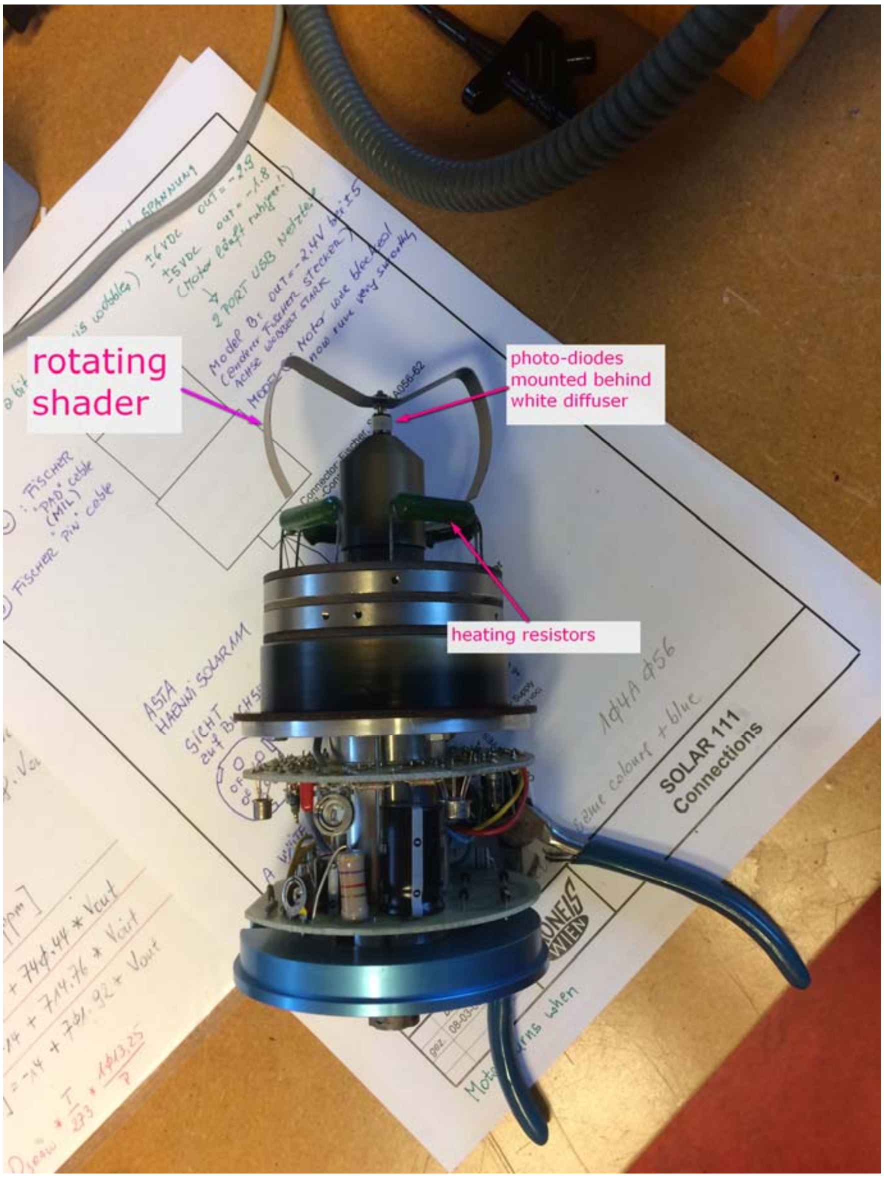

Fig.6. Open Haenni Solar 111

So the principle of measurement uses the light (or temperature) difference between shaded and un-shaded elements. The number 120 W/m^2 was probably not in use from the start on, as I remember reading a test where this threshold was found to be 150 W/m^2 for the Haenni.

The electrical power requirements are a bit unusual: 56 VAC for the heating; depending of the external temperature the needed heating power may change from 1 to 30 Watt !). A second bipolar -5 - 0- +5 VDC power supply is used to power the motor and the electronics –mostly transistors and operational amplifiers.The output signal is typically +4VDC when the sun shines and -4VDC when it does not.

I did not found much information on the Haenni Company. It's last instrument was the Solar 130 using silicon radiation sensors; the company stopped operation during the nineties **[ref. 4**]. The Haenni Solar 111B (I am unsure how this variant differs from the 111 besides the connector) became the standard sunshine duration sensor in the TAWES network (Austria, **[ref.5, 6]** from 1981 on. So we assume that our vintage models are from the beginning nineties.

4. The help of Kroneis GmbH

The 3 specimens we received from ASTA had cut-off shielded cables with 8 individual wires. I was unable to find any indication on the pin-out, until by chance I read that the Austrian company KRONEIS **[ref. 7]** sells a sunshine sensor, that is an adapted (refurbished?) version of the Haenni Solar 111. I guess that Kroneis bought a stock of Solar 111 instruments from Haenni and Lufft (another German company building and selling meteorological equipement) when Haenni ceased operation, and they made some changes that are not publicly documented.

In the 1990's I was the leader of project PHYMOES, a research project on underground climatology; in this project we used a dew-point sensor from Kroneis to measure the very high humidity levels (a normal capacitive humidity sensor is useless in such an environment). So I mailed Kroneis as a former client asking for help on the pin-outs of the Haenni Solar 111. A couple of hours later a received an answer from it's CEO Mr. Martin Moser with everything I needed This really was a fast help, and it is highly appreciated!

Fig. 7. The Kroneis company

Knowing the pin-out of both the old MIL and newer Fisher connectors allowed to make a quick check; all three sensors seemed to work, after loosening with a gentle shake the motors which were stuck by the decade long inaction. I built a special power supply with a second-hand 56 VAC transformer found on eBAY, and assembled the -5-0-+5 VDC power-supply using 2 normal USB chargers:

Fig.8. The home-made power supply for the Haenni Solar 111

The instrument (a 111 type, serial #91123648) and Solar 111.999228) was definitively installed in February 10th 2020, and its output sampled every minute by two loggers: a small HOBO type logger from ONSET Computer Corp. (USA), and a vintage refurbished Mikromec logger from Technetics Datenlogger u. Messtechnik GmbH (Germany); the later was a leftover from the PHYMOES project.

5. The 54 days measurement series

We now have a first uninterrupted series of 54 days, from 11-Feb to 04-Apr 2020. The comparison will show the daily sunshine hours measured by the Haenni Solar 111, and the same SD computed using Olivieri's method from the data of the meteoLCD SMP10 pyranometer from Kip&Zonen. Here the plot of both series:

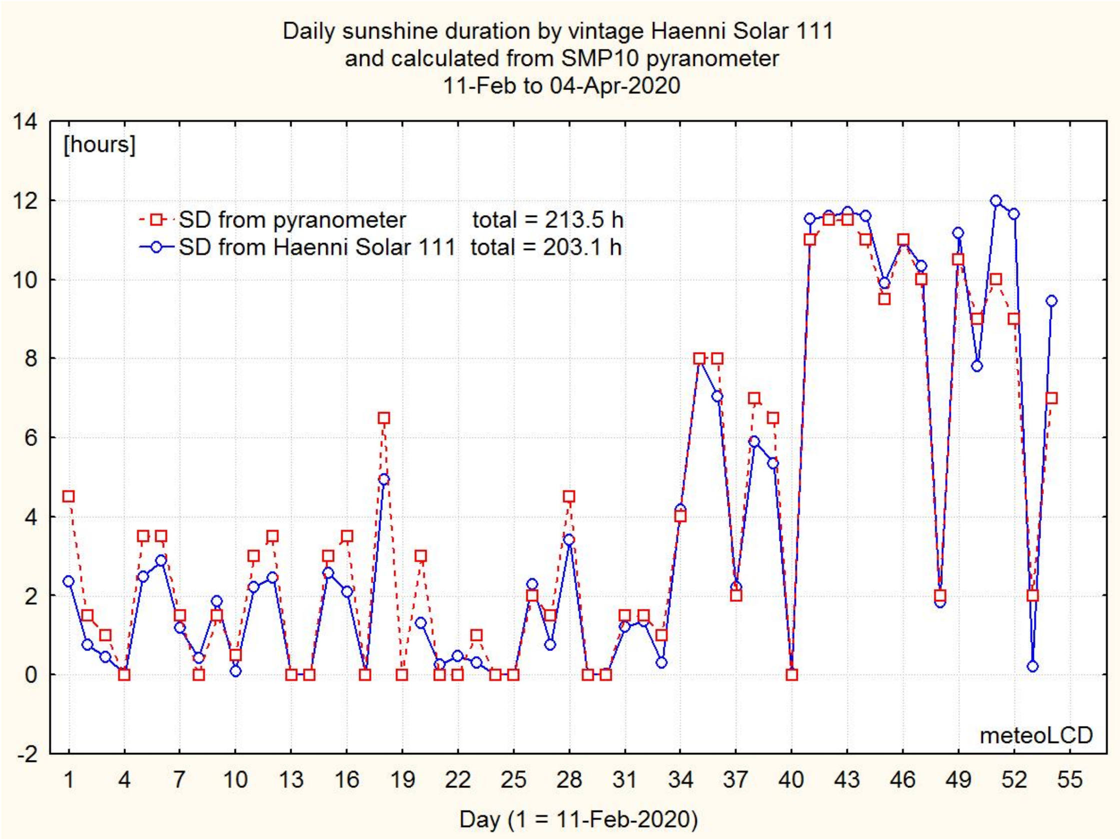

Fig.9. The two series of daily sunshine hours

Clearly the Haenni measures a bit too low, but its total differs from the "correct" reference value only by about 5% . Actually this "good" behavior comes as a surprise. According to Kroneis, the instrument should be recalibrated at least every 2 years, and this period has been exceeded by at least a factor 6. The vintage Haenni follows very nicely the up and downs of the reference signal. Let us plot the "real" values against the Haenni and make a linear regression to compute a calibration factor. An affine fit suggests to apply the function 1.1982-1.805*Haenni to yield "correct" values with an R^2 = 0.9545.

A regression through the origin does not lower R^2 by much (from 0.95 to 0.94). So we could conclude on using the multiplier 1/0.971224 = **1.03** as a calibration factor for the vintage Haenni Solar 111 (fig. 10).

The SD data for the month of March 2020 from the Luxembourg official meteorological station at the Findel airport (OMM index 06590, **[ref. 8]**) and from the AgriMeteo (former ASTA, **[ref. 9]**) are available now.
As usual, the Findel SD's are higher than those measured at meteoLCD (Findel has an higher altitude of 376m asl and does not lie in a valley). Findel uses both

a Vaisala DSU12 (precision 10% only) and a Campbell-Stokes; it is not known if the published SD data come from the Vaisala or the CS.

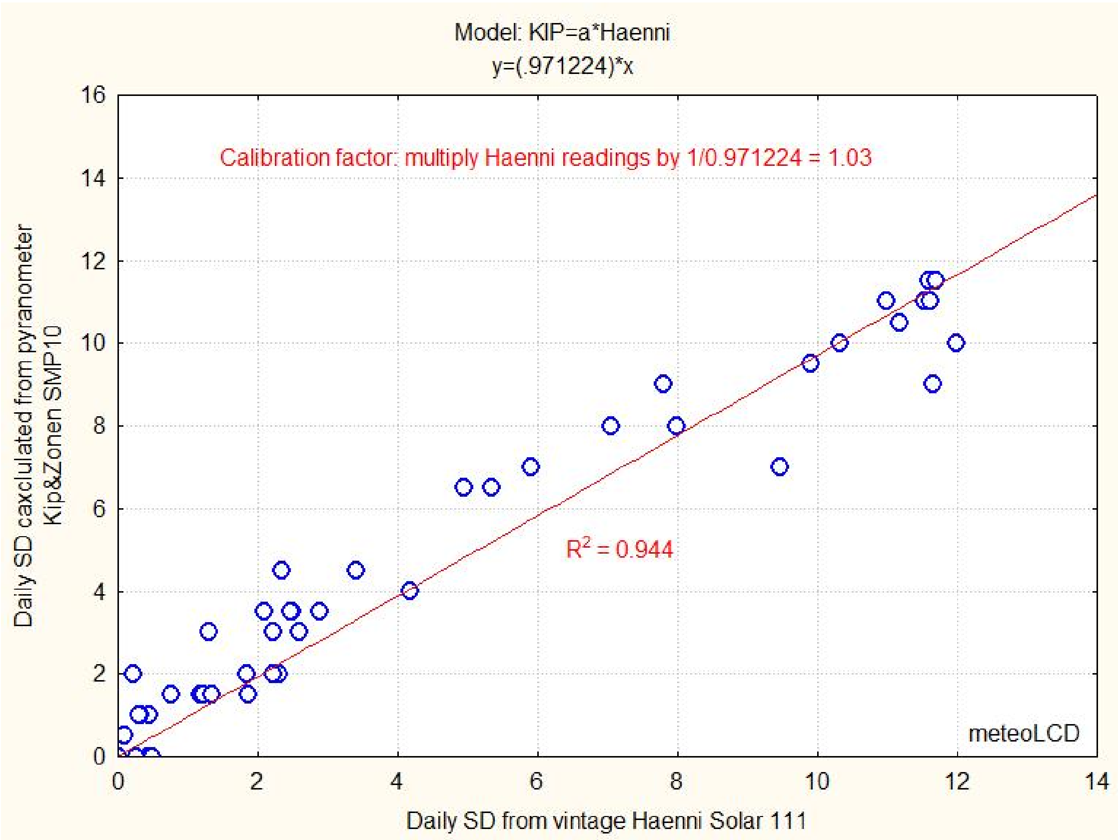

Fig.10. Real SD versus Haenni suggest a calibration multiplier of 1.94655

The Echternach station of AgriMeteo lies in a similar landscape as Diekirch, and it has both a pyranometer and sunshine sensor (probably a CSD3). Both SD and SI readings are close to those of meteoLCD.

Sunshine hours SD and total solar irradiance SI March 2020	Meteolux Findel 376m asl	AgriMeteo Echternach 234m asl	meteoLCD Diekirch 218m asl	
	DSU12 ? CS ?	CSD3?	from pyranometer	Haenni Solar 111
SD (h)	171.5	149	150	142.9
SI (kWm^{-2})	unknown	96	91.3	

6. Conclusion

Reviving an old sunshine sensor was an interesting endeavor. The aim is not to use it as our principal means for SD detection, but to show a vintage sensor in operation. The spinning shader brings something of an "aha" effect to visitors, and makes quite a difference between this device where something moves constantly and our other solar sensors without moving parts (UVB, UVA and SI), which could be seen as dormant.

When one takes into account that expensive sensors like the Vaisala DSU12 has an incertitude of 10%, the 1.03 multiplier for the old Haenni Solar seems like an excellent qualifier. We live in a world drowning in environmental data; these are often taken by the public as perfect, without any consideration to the sometimes very big uncertainty they carry. Working on a vintage instruments forces one to reflect on this important aspects of precision and accuracy. That a very old sensor which lied dormant for so many years does behave so well speaks for the talents of the Swiss engineers and scientists who invented and built It !

I conclude by thanking the Kroneis GmbH and it's CEO Martin Moser with all my heart; without their quick help this exciting revival experience would not have been possible.

Francis Massen
manager of meteoLCD

References:

[1] Massen, Francis, 2001: Sunshine duration from pyranometer readings

https://meteo.lcd.lu/papers/sunshine_duration_from_pyranometer/Sunshine_duration_from_pyranometer_readings.pdf

[2] Oliviéri, Jean: Aspect géométrique du rayonnement solaire. Note technique 36. Meteo France, Dec. 1999

[3] Kerr A.,Tabony R.: Comparison of sunshine recorded by Campbell-Stokes and automatic sensors. RMetS, Weather, April 2004, vo. 59, No.4, pp.90-.94

[4] Baumgartner et al. A comparison of long-term parallel measurements of sunshine duration obtained with a Campbell-Stokes sunshine recorder and two automated sunshine sensors

https://link.springer.com/article/10.1007/s00704-017-2159-9

[5] PES, https://www.pes.eu.com/solar/offering-so-much-to-solar-whatever-the-weather/

[6] G. Pevny, M.Mayer: TAWES
https://www.wmo.int/pages/prog/www/IMOP/publications/IOM-96_TECO-2008/P2(34)_Pevny_Mair_Austria.pdf

[7] Kroneis GmbH Iglaseegasse 30-32 1190 Wien
https://www.kroneis.at/ office@kroneis.at

[8] Meteolux, Findel airport: https://www.meteolux.lu

[9] AgriMeteo weather stations: https://www.agrimeteo.lu

History:

09-Apr-20

v. 1.0a The indication that 1 mV corresponds to 70 W/m^2 given at page 8 is correct for some pyranometers, but not for the Haenni Solar 111. This sentence has been removed.