Solar Scintillation Monitor

User manual

Special thanks to M. Edward Joseph Seykora for his authorization to use his initial design and his kind wish of success, and both Jean Pierre Brahic and Christian Viladrich for their extensive testing.

Quick start

Presentation

Thank you for buying Airylab's Solar Scintillation Monitor (SSM). This device will allow you to determine instantaneously the seeing value in ArcSec at your specific location by daylight for solar observation and imaging. The SSM has been designed for three main applications:

- *Help you to find the best observation site for solar visual observation and imaging. The small handheld form factor makes it very easy to bring to potential locations for a quick survey.*
- *Determine the best seeing time for your observation location. Used with its data acquisition software, you may collect data over the day to see the general seeing evolution over time.*
- *Directly command image acquisition when used with Genika Astro. In that case, Genika Astro connects to the SSM directly and trigs acquisition from the camera when the seeing goes below a predefined value. For more information about this topic, please refer to Genika Astro user manual.*

Operating the SSM

SSM location

Be very careful about the location of the SSM during measurement. It should always be located near the telescope entrance pupil, or its projected location.

If positioned too far from the telescope, the readings reflect only the seeing at the SSM actual position rather at the telescope aperture. Both may be very different depending on the environment.

Example: when the SSM is placed upon a metallic or plastic table top, the seeing is deeply affected by the very local turbulence caused by the table surface heating.

The SSM has an external sensor connected by a RCA plug.

The sensor should be located next to the telescope entrance pupil. Use the provided plastic support to conveniently attach it.

SSM sensor installed on a HaT telescope

Use the provided cable to connect the sensor to the SSM RCA plug. The sensor may be connected directly to the SSM without cable.

Power supply

The SSM standalone can be powered from its jack plug. It accepts 6 to 12V input. Note that if powered from a car battery, the SSM should not be used for an extended period of time as the battery delivers about 13,8V unloaded and the module may overheat. You may use a rechargeable battery pack or a LIPO battery as the power consumption is below 100mA.

You may also power the SSM through its USB port when connected to a PC or to a generic USB power supply.

Readings

The internal OLED screen gives three values updated twice per second.

Input

The input gives the level incoming light on an arbitrary scale. The photodiode sensor has an effective operating angle of 180°. Depending on the SSM orientation and sun elevation, this value would change along the time. **The input value should be kept between 0.5 and 1 at all time.** If the value goes below 0.5, the SSM stops to calculate the seeing value. That can be the case when clouds pass by. If the value goes over 1, seeing values are calculated but with less accuracy as the input amplifier chain may clip some data. You may adjust the input back to less than 1 either changing the SSM orientation, or using the internal rotating trimmer located next to the photosensor with a small flat screwdriver.

Note that it is possible to set the trimmer in a position that allows to run a full sun cycle with input between 0.5 and 1.

Seeing

This value gives the seeing in ArcSec. The value is calculated from the sun light high frequency scintillation. Very small variations of the light reflect the actual low altitude turbulence that is preponderant during daylight (Seykora 1993, Beckers 1993-2009). The SSM measures the incoming light 1400 times twice per second and calculates the seeing value.

Seeing varies on a high frequency that explains the constant reading fluctuations. For short high speed imaging run, the fast refresh rate of the SSM allows to trig image acquisition at the proper time when coupled with Genika Astro.

1mn Avg

One minute moving average seeing value. Indicates “Low” is the number of data is too low.

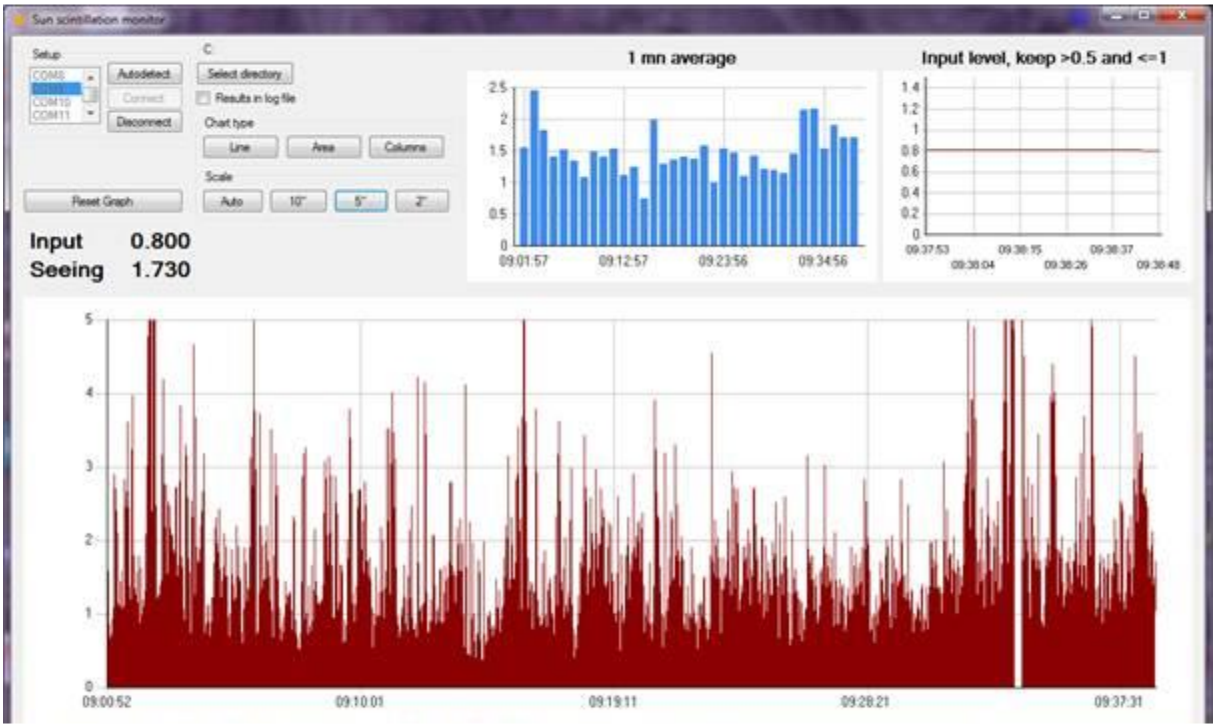
Using the SSM with its Windows application

Installation

Install the SSM software.

The SSM uses an Arduino module as a main CPU. The drivers are provided with the SSM application in the drivers folder. **The driver is automatically installed during the SSM software installation**. You may install it manually if needed. Depending on your operating system (x86 or x64), execute the *dpinst-amd64.exe (Windows 64 bits)* or the *dpinst-x86.exe (Windows 32 bits).*

You may connect the SSM to the USB port and launch the SSM software:



The SSM create a new COM port on your PC. If you don't have any other Arduino based system, you may try the autodetect option. You may also manually select the COM port. Then press the connect button. After a few moments, the readings from the SSM are displayed on the charts.

- The upper right chart displays the input level evolution.
- The lower large chart shows the instant seeing value evolution. Three scales and three chart types are available from the button above the chart.
- The upper center chart resumes the long term evolution from the average value on a full minute.

You can log the seeing values in a text file by checking the *result in log file* checkbox. The file is automatically created in the folder that may be selected with the button *Select directory*. A new file is created if you uncheck/recheck this box.

You may also reset the main chart at anytime; this does not stop the data logging in the file.

General solar observation guidelines

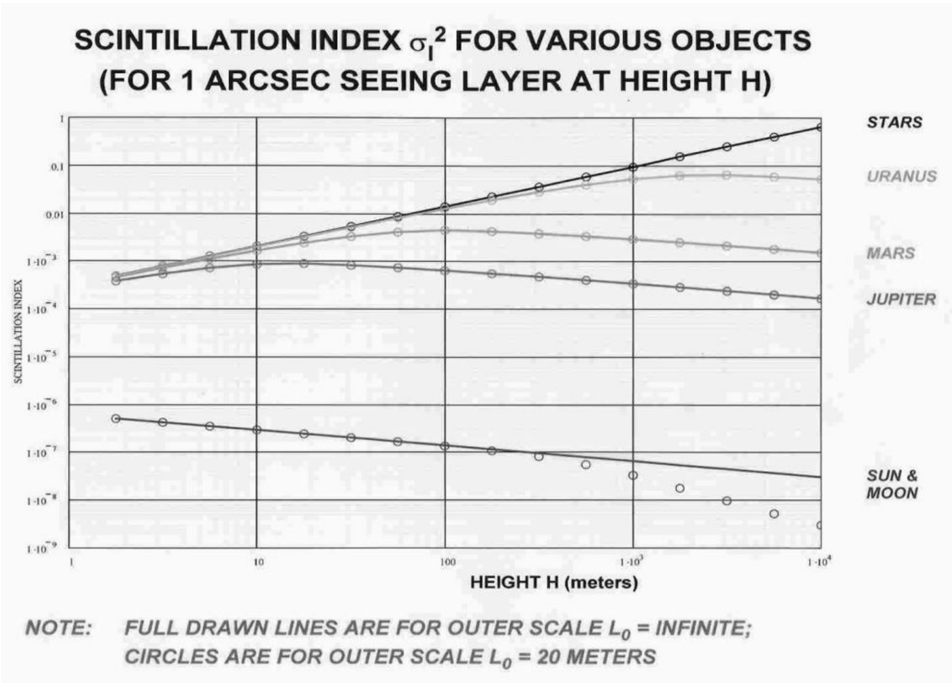
As a general guideline, your solar telescope should be used at a position that minimizes the first meters turbulence sources:

- Avoid concrete, choose if possible grass ground.
- Water surrounded locations shows minimal low layers turbulence.
- Higher is better. If you have an elevated terrace, it could be a good location. Mountain site are usually better, but avoid mid slope positions as they present ascending air currents.
- Avoid concrete or stone walls close to the telescope.

The seeing also varies deeply during the day. Except on specific location such as high mountains top, the best seeing is usually during the morning, and the second part of the afternoon.

Understanding what the SSM measures

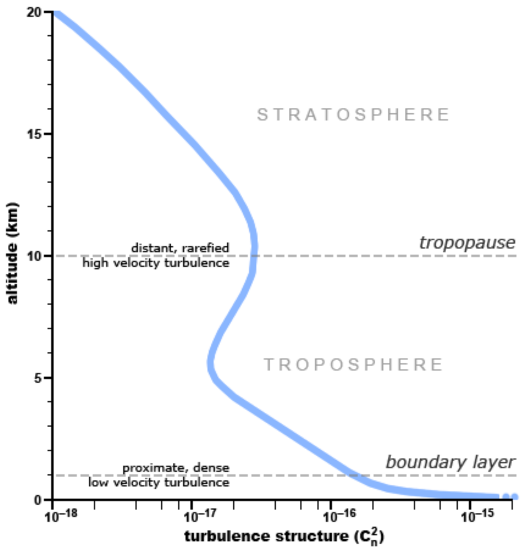
Scintillation from an extended object such as the Moon or the Sun is mainly caused by low layers up as shown below. This is the exact opposite situation when considering stellar object. For those, scintillation is rather due to higher atmospheric layers at the jetstream level.



From USING THE SCINTILLATION OF EXTENDED OBJECTS TO PROBE THE LOWER ATMOSPHERE, JACQUES M. BECKERS

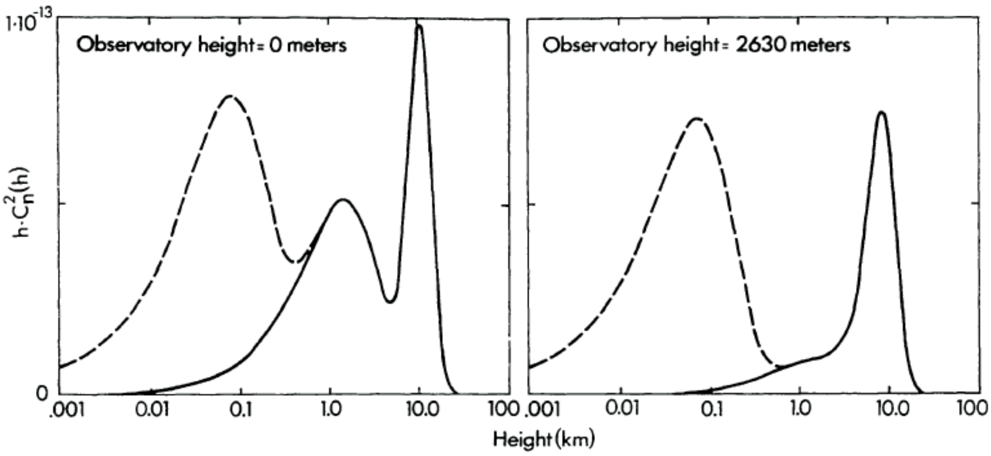
For the sun, the scintillation level is about 7E-7 of the total light in the first ten meters, 1E-7 at 100m and 5E-8 at 10km.

On the other hand according to the Hufnagel/valley model that is widely accepted, atmospheric turbulence originates mostly from both the jet streams at the tropopause altitude (7-12km) and the lower layers below 5 km:

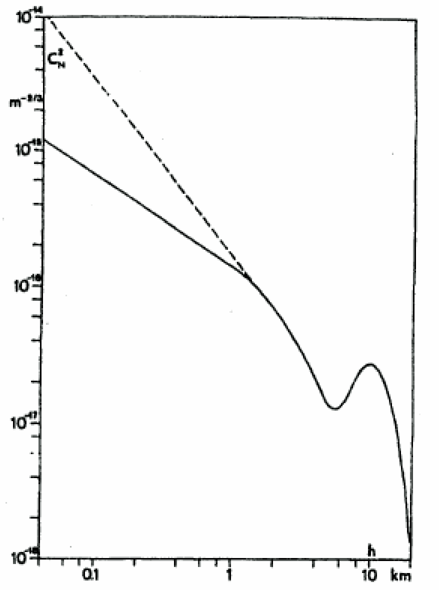


The Hufnagel Valley model, Hufnagel/Valley, 1979

That is even truer when considering daytime turbulence. If you consider the integral of the turbulence on both graphs below, you can see that most of it in due to the first kilometer by day.



Dotted line is daytime. Beckers, 1993



Dotted line is daytime, Roddier 1981

Scintillation analysis with a dynamic better than 10^7 as used in the SSM allows to measure contribution to the turbulence from the lower layers that are the main contributor to daytime seeing. Professional observatories are using photodetectors linear arrays SHABAR systems that can spread out the contribution to the turbulence of the different layers of the atmosphere. The SSM is a simplified low cost version for amateur solar astronomers using a single photodiode. Its dynamic is able to show turbulence of the first couple of kilometers at least.

It is important to remember that this measurement is less sensitive to higher layers induced turbulence (i.e. jetstrams). With the same seeing readings on two different days, the actual turbulence may differ due to different jetstreams speeds.

Shortened bibliography

JACQUES M. BECKERS (2009) USING THE SCINTILLATION OF EXTENDED OBJECTS TO PROBE THE LOWER ATMOSPHERE. Optical Turbulence: pp. 23-25.

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