SQMDroid - A universal SQM measurement device

Andreas Hänel[1] and Thomas Hänel[2]

[1] *Museum am Schölerberg, Osnabrück, 49082, Germany, ahaenel@uos.de*

[2] *Inst. of Computer Science, University Osnabrück, 49069, Germany*

Abstract

We present a method to combine a SQM-LU with an Android smartphone to simulate the classical SQM-L for individual measurements, SQM-LU for continuous, vector SQM-LU-DL-V, and the roadrunner SQM. For this purpose, the software SQMDroid has been developed.

The SQMs

The Unihedron Sky Quality Meter SQM has become a popular instrument for measuring sky brightness (e.g. Kyba et al., 2015). It is available in different versions:

SQM and SQM-L directly display the sky brightness in magnitude$_{SQM}$ arcsec^{-2} after some integration time depending on the sky brightness.

SQM-LE, -LR, -LU have no display but provide Ethernet, RS232, or USB interfaces to be connected to a computer, which stores the measured brightness values at specifieded time intervals.

SQM-LU-DL is the USB version delivered with an internal data logger that must be programmed with a computer.

The vector SQM

Normally brightness values are measured near the zenith, but to get a more representative depictione for the whole sky hemisphere, measurements at different altitude and azimuth directions can be taken (Zamorano et al., 2014).

This measurement method was integrated in the recent model **SQM-LU-DL-V** (vector) which contains an accelerometer/compass module allowing measuring altitude and azimuth of the instrument. From the measurements a contour map of the sky brightness can be generated with the included software (Unihedron, 2016).

The Roadrunner

Another utility called Roadrunner was developed by *Daniel Rosa Infantes* from the Sociedad Malaguena de Astronomía (2011). The Windows PC software takes simultaneous measurements of the sky brightness with a SQM-LU mounted on the roof of a car and the position is measured simultaneously with a GPS. This allows for efficiently taking a large number of measurements over large areas, limited by obscuration (through bridges, trees) or road lighting. Similar methods are possible with a Raspberry Pi or with custom-built solutions using low-cost microcontrollers as proposed by *Espey and McCauley* (2014)..

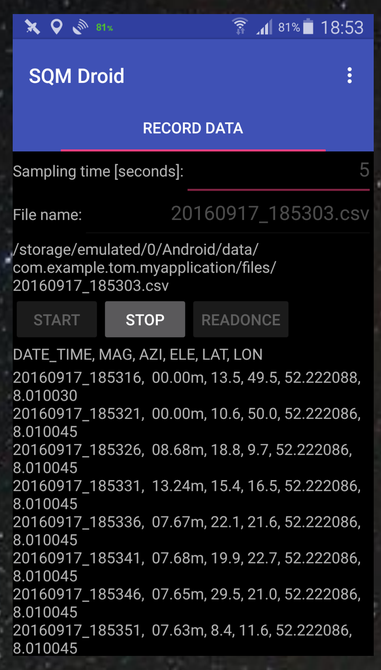
SQMDroid

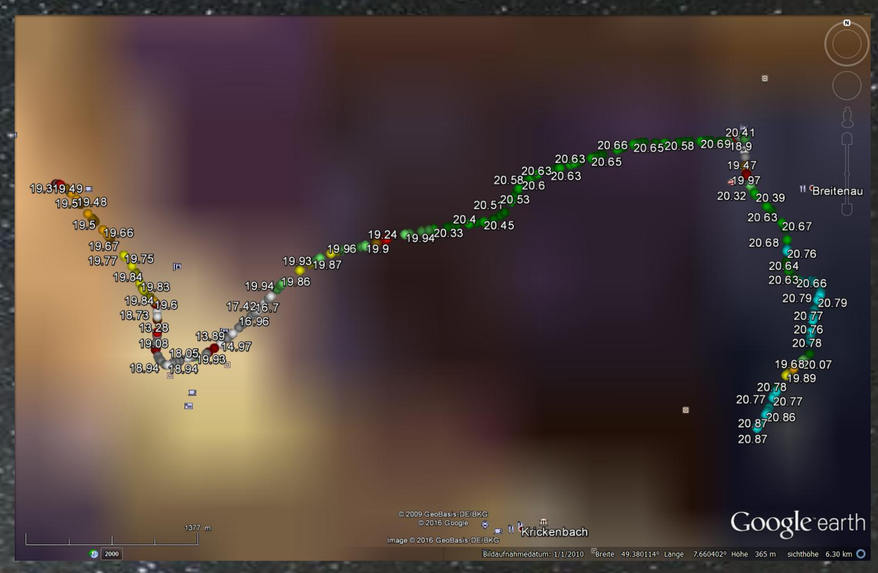
Android smartphones contain a multitude of sensors such as GPS, accelerometer, gyroscope, and compass. Higher quality models can also be used as USB hosts, called USB On-The-Go (OTG). Therefore we connect a SQM-LU directly to an Android smartphone with an OTG adaptor cable and mount both devices parallel.

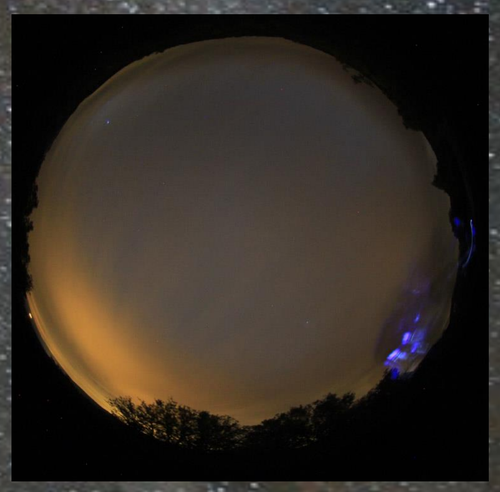
Simultaneous measurements of time, position (with the internal GPS), orientation (with the accelerometer & compass), and sky brightness are possible, integrating all different SQM models into one instrument!

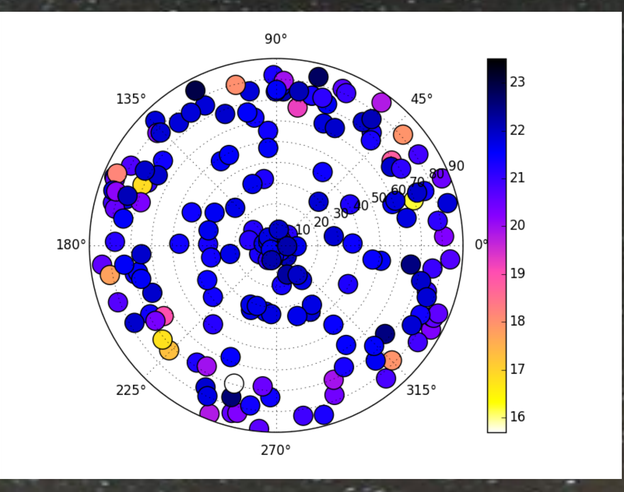
We developed the Android app SQMDroid which uses the Android Terminal Application provided by FTDI to configure the UART interface in the SQM-LU and transfer data from it. The app allows taking individual measurements manually or continuously at specified time intervals. These are stored in a .csv file (with date, time, mag, azi, alt, lat, long) in the internal memory or sd card of the smartphone. The following modes are possible:

- As with handheld SQMs individual zenith brightness measurements can be taken manually with the automatic registration of date, time and position.
- Continuous measurements can be taken at a fixed place with a given time interval like the SQMs with interface.
- Using it on a car (or due to the compactness by feet or a bicycle) measurements at different positions can be taken like with the Roadrunner software.
- Like with the SQM-LU-DL-V measurements towards different azimuth and altitude directions can be taken (vector mode).









Measurements and Usage

For the measurements we used a tablet Nvidia Shield K1 and mainly a smartphone Samsung Note 3 (SM-N9005).

The **positional accuracy** of the GPS depends mainly on how good the contact to the satellites is. Generally it is better than 5 meter as overlays of the measurements over GoogleEarth show.

The **accuracy of the orientation sensor** is more critical. While the altitude is measured with an accuracy of 1-2°, the azimuth angles have errors up to 10°. Therefore it is essential to calibrate the compass of the smartphone before starting vector mode measurements.

The **energy consumption** of the SQM-LU is 18 mA, which is low compared to the smartphone with 450 mA. We observed that during 30 minutes with continuous low screen illumination the battery charge reduced by 5%.

Further developments:

With further developments the following additions could be implemented:

- Measurements will be directly shown on a map (eg. on OSM)
- Data is transmitted to the data base of Globe at Night
- Using the vector mode will be supported by giving advice for the direction of measurement (like in 360° photo sphere).
- Adaptive measurements with longer integration times at lower sky brightness (at 24 mag/arcsec² 60s integration seems to be necessary!)

References:

Espey B, McCauley, J (2014) Initial Irish light pollution measurements and a new Sky Quality Meter-based data logger, Lighting Res. Technol. Vol 46, 67-77.

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Unihedron (2016) Sky Quality Meter –LU-DL-V; http://www.unihedron.com/projects/sqm-lu-dl-v/

Zamoran J, Sánchesz de Miguel A., Nievas M Tapia C. (2014) NixNox procedure to build Night Sky Brightness maps from SQM photometers observations, LICA report.

Background picture: IDSReserve Westhavelland (A. Hänel)