Calibration of TESS, the STARS4ALL night sky brightness photometer

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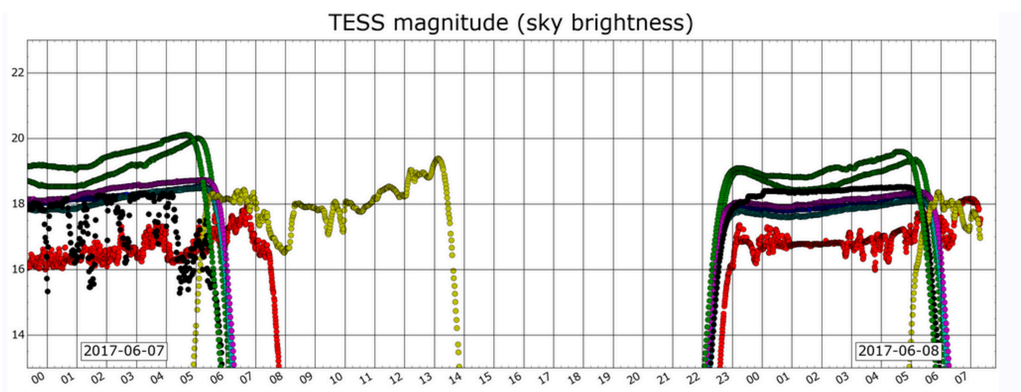
TESS Night Sky brightness photometer

To monitor NSB from fixed places or in the move.
Measures the sky temperature to estimate the cloud coverage.

Data is sent automatically to the data repository using IoT (Internet of Things) protocols.

Open hardware, software and data.

Additional filters can be included inside the weatherproof box.



Hardware

The sky brightness detector is a TSL237 photodiode that convers light to frequency. It is the same sensor used by the SQM photometers. However the bandpass is more extended to the red range with the use a the dichroic filter.

(1) The light from the sky is collected with the optics that includes a dichroic filter to select the bandpass. The filter fully covers the collector.

(2) The sensor (not seen in this picture) is located in a printed circuit board along with the custom made electronics.

(3) The WiFi module. An antenna inside the box extends the WiFi range

(4) IR sensor to measure sky temperature.

(5) The heater is switched on when needed to get rid of condensation on the window (6)

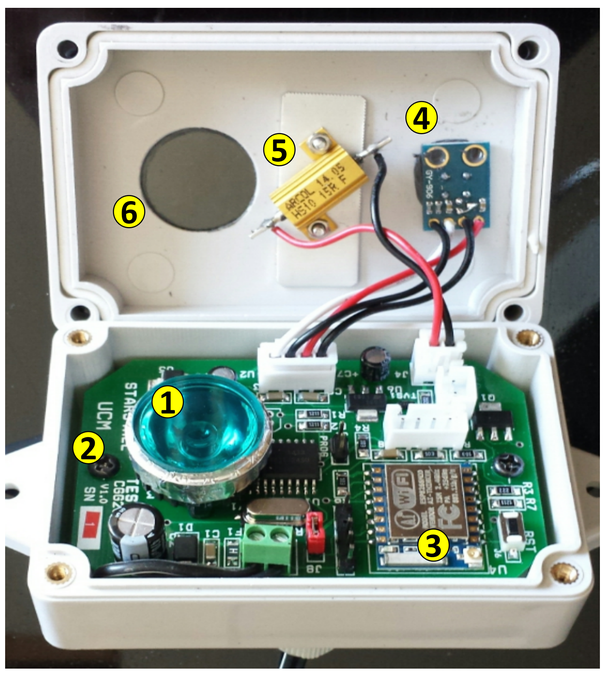


Figure 1. The inside of enclosure with the optics and electronics of the TESS-W photometer.

Spectral response

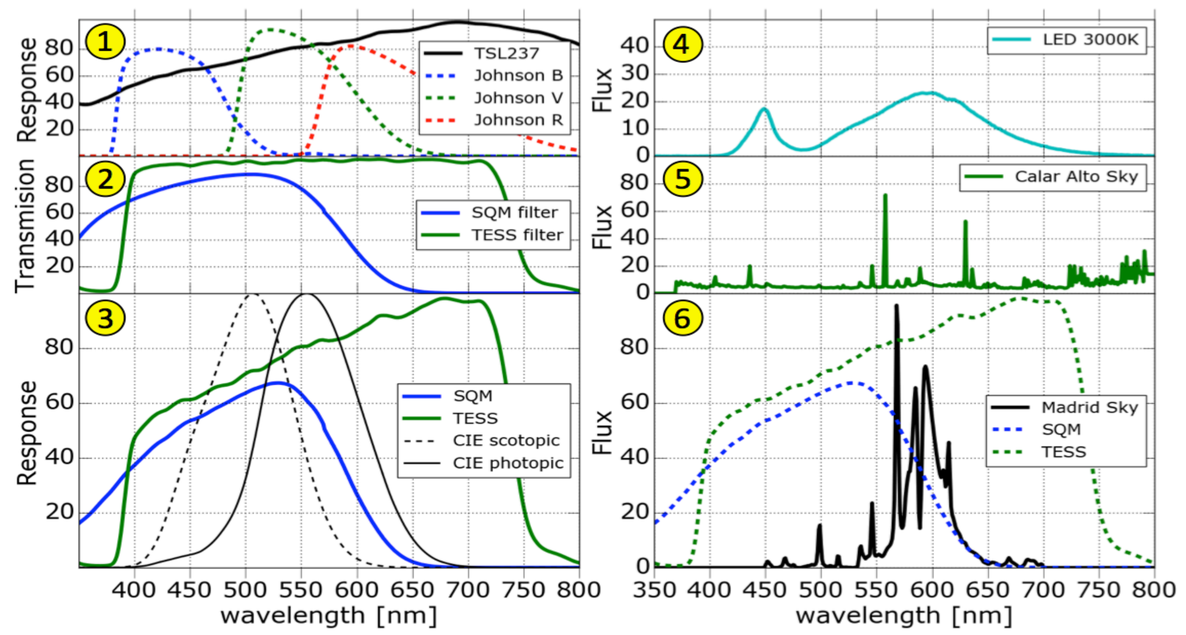


Figure 2
1. Spectral response of the TSL237 sensor.
2. Transmission of the HOYA CM-500 (BG39) used by Unihedron SQM and that of the dichroic filter used in TESS.
3. Combined response of filter and sensor.
4. 3000K LED spectrum.
5. Calar Alto Sky spectrum (Sánchez et al. 2007PASP..119.1186S)
6. Spectral response of SQM and TESS over the night sky spectrum of Madrid (Aubé, SAND spectrometer)

Optical lab tests

We are using an Integrating sphere with several ports for cross calibration and to compare with SQM data.

Light from a LED with spectrum centered in 596 nm and FWHM of 14 nm is measured from a master TESS, a master SQM and the testing TESS to assign a zero point before sending the photometer to the user.

The absolute calibration will be performed on LICA-UCM optical lab using a calibrated photodiode and also with data from the astronomical observatories including observatorio UCM.

For the first 39 TESS photometers the mean value of the measured zero points is ZP = 20.44 while the SQM used as comparison has a ZP = 19.89.

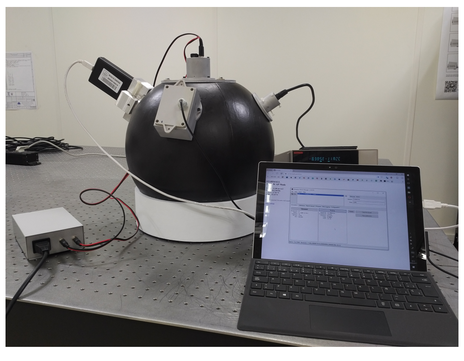


Figure 3. Instrumental setup for calibration.

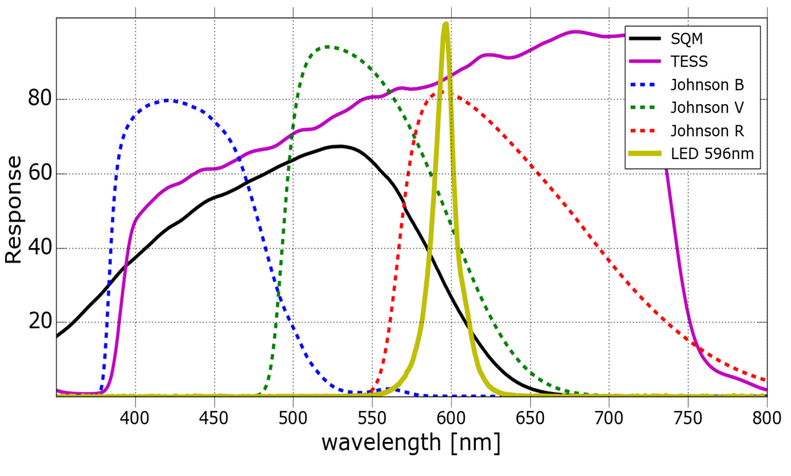


Figure 4. Comparison of the TESS and SQM responses with he Johnson B. V and R photometric bands.
The yellow line represents the emission spectrum of the LED used for calibration.

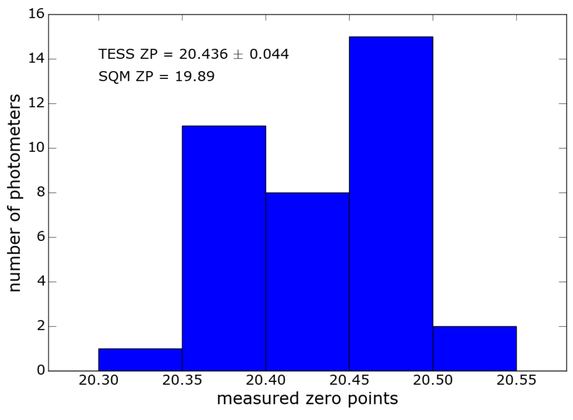


Figure 5. Histogram showing the differences in zero points among the TESS photometers. These offsets are mainly due to differences in sensitivity of the TSL237 detectors.

Field tests

The first 12 working units of the TESS photometer have been assembled and they are being tested under both bright and dark skies.

Most of the locations are fixed stations of the Spanish Network of Light Pollution Studies which provides SQM readings for intercomparison.

Preliminary results of the field test show that TESS-V1 photometer is around 0.5 magnitudes more sensible than the Unihedron SQM photometer on polluted skies as Madrid.

The offset between SQM and TESS depends on the color of the sky, as expected.

Some TESS in dark places (observatorio del Teide, observatorio de Javalambre, COU-Montsec will provide data to compare TESS and astronomical photometric bands under dark skies.

Figure 6. (Top) NSB data obtained at UCM observatory using AstMon astronomical camera, SQM and TESS along one night .

(Left Bottom) SQM vs. TESS measures and dependence of differences between TESS and SQM with the sky color.

(Bottom) Several TESS being tested at UCM observatory with the help of AstMon, SAND spectrometer and SQM photometers.

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The TESS photometers are being tested at Laboratorio de Investigación Científica Avanzada (LICA), a facility of the UPM-UCM Campus de excelencia Internacional.

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