Measuring Night Sky Brightness with smartphones: The new version of the Dark Sky Meter App

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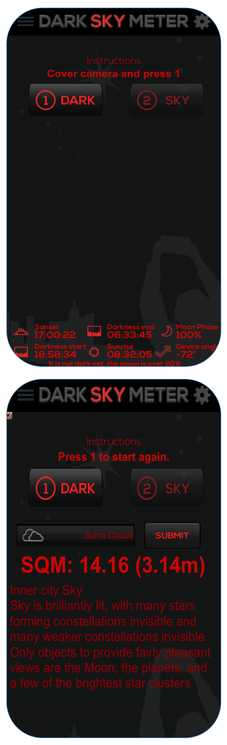
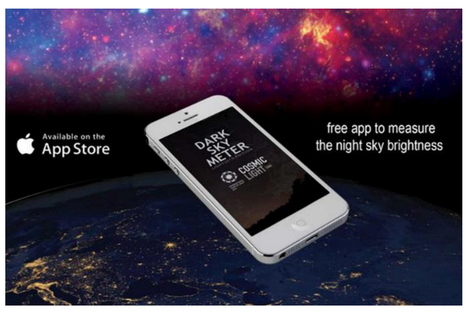
The Dark Sky Meter app

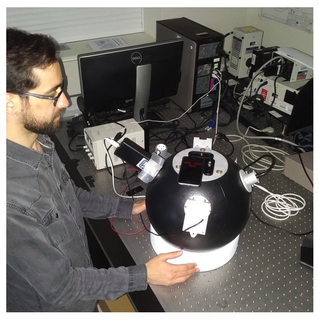
- The Dark Sky Meter was developed by amateur astronomers as a cheap alternative to expensive light meters.
- The DSM app converts the smartphone into a scientific instrument to measure Night Sky Brightness.
- The main advantage is that any interested citizen is provided with a photometer in his pocket.



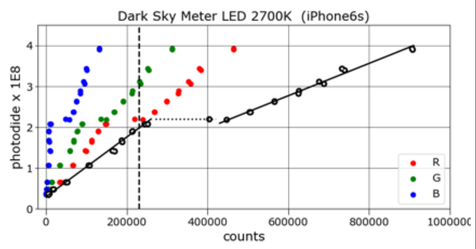


The calibration problem of the DSM app

- First versions of DSM read the light coming from the sky using video and performing statistics with several frames.
- As the video frames were saved as jpeg images the linearity were lost.
- The intensity of the jpeg images depends on the brightness of the sky different gamma factors). The empirical calibration was a nightmare.



- We made a controlled calibration at LICA optical laboratory using an integrating sphere with the smartphone and the SQM in ports with the same radiance.
- The figure shows a linearity test. There are two gamma factors for each of the R, G and B channels and also for the sum (R+G+B black points) depending on the brightness.



The new approach

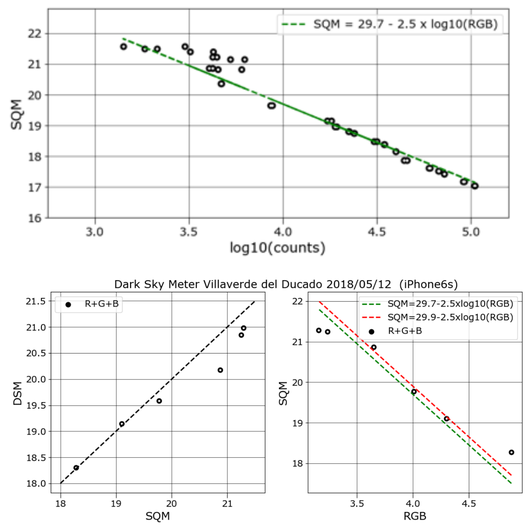
- The new version of the DSM app is being developed with a different approach: using camera RAW pictures.
- The camera should be is a linear device and the calibration will be more reliable.
- We are characterizing smartphones to determine the sensitivity and spectral response of their cameras.
- We intend to provide laboratory and field calibrations and to refine the calibration using the users feedback (citizen science).
- This step is necessary due to the variety of smartphone cameras on the market.

- DSM is a Light Pollution Initiative of the STARS4ALL Foundation

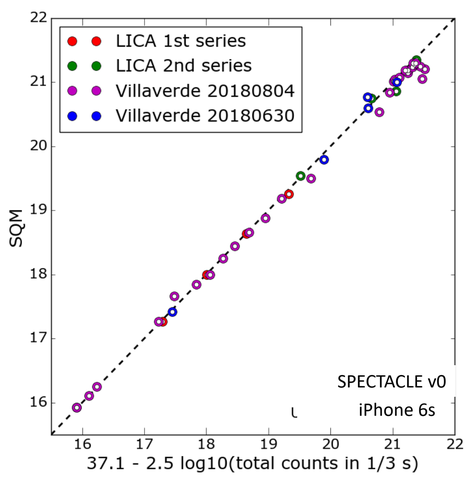
STARS4ALL

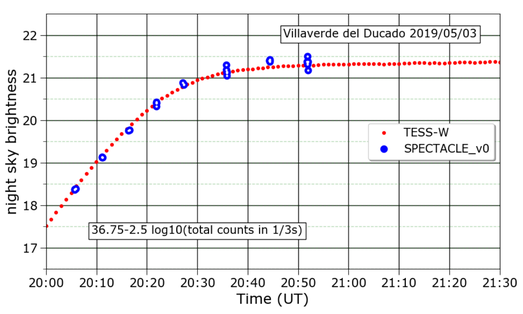
Laboratory and field test

- The laboratory setup with integrating sphere allows to feed light in a wide range of brightness to both the smartphone and photometer at the same time.
- We are using the sum of R+G+B channels for the whole chip to get a 'total' number of counts.
- When comparing with a photometer it should be noted that the fields of view are different.
- For low brightness the subtraction of the dark value is mandatory and very important.
- Results for intermediate versions of the app are shown at right showing problems at low brightness levels.

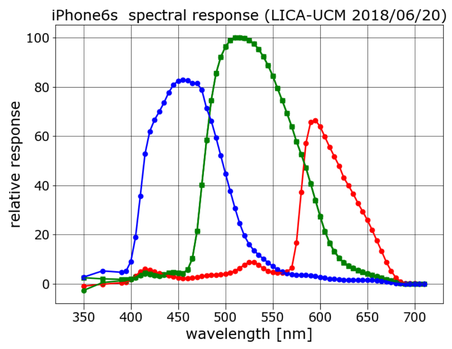


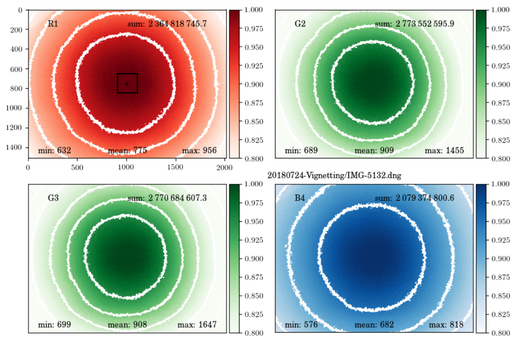
- Using a preliminary version of the SPECTACLE (an smartphone app to record RAW images) we made measures both at laboratory and field (rural area, Villaverde del Ducado) with very promising results.
- We show at left the good fit after comparing an SQM reading and the total counts from pictures taken with an iPhone 6s.
- The plot at bottom was obtained during a twilight to get a wide range of night sky brightness.





Calibrating smartphone cameras





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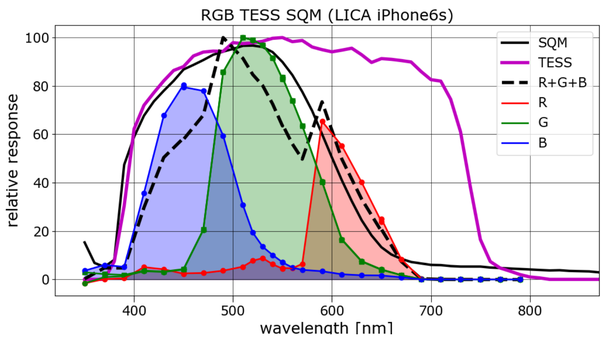

Standardized Spectral and Radiometric Calibration of Consumer Cameras

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- We have developed a standardized methodology and database (SPECTACLE) for spectral and radiometric calibrations of consumer cameras, including linearity, bias variations, read-out noise, dark current, ISO speed and gain, flat-field, and RGB spectral response.
(Optics Express in press https://arxiv.org/abs/1906.04155)

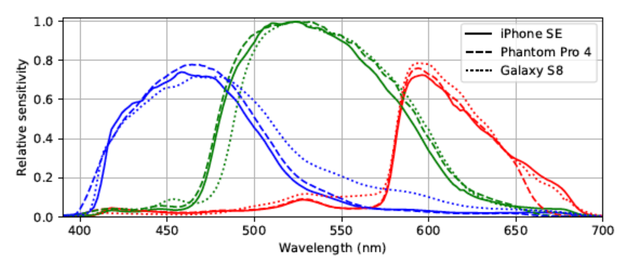
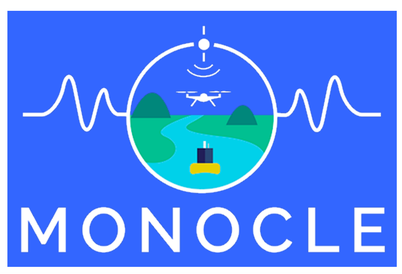


Fig. 10. Spectral response curves of the iPhone SE, Galaxy S8, and Phantom Pro 4, derived from monochromator data. The responses are normalized to the global maximum per camera, giving relative sensitivities. G is the average of the G and G_2 responses over the wavelength axis, since no significant differences were found. RMS errors are ≤0.005.

Collaboration among European Projects

European Commission | Horizon 2020 European Union funding for Research & Innovation

- We are using a modification of the iSPEX app developed within the MONOCLE project http://www.monocle-h2020.eu.
- The iSPEX app is an innovative way to measure tiny particles in the atmosphere, or atmospheric aerosols, that contribute to air pollution and its impacts on our health and environment in an as-yet poorly understood way.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776480.

- The improvement of the Dark Sky Meter app is being made with the of the help of the STARS4ALL Foundation http://stars4all.eu/ .
- The STARS4ALL was an European project raising awareness about the negative effects of artificial light on human wellbeing, biodiversity, visibility of stars, safety and energy waste.

STARS4ALL

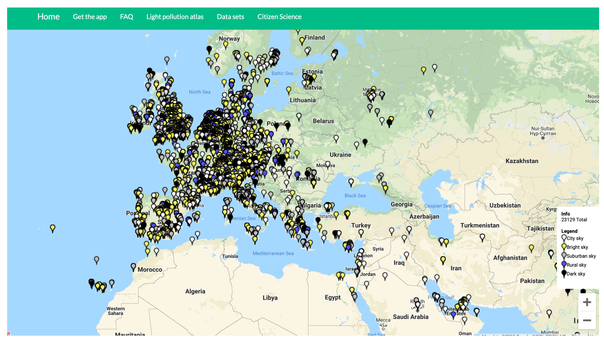
STARS4ALL is a project funded by the European Union H2020 Programme (688135). This is part of Digital Social innovation

- ACTION https://actionproject.eu/ will transform the way we do citizen science today from a predominantly scientist-led process to a more participatory, inclusive, citizen-led one.
- ACTION takes on board the diversity of the citizen science landscape and the challenges citizen science teams have to meet by providing ad hoc methodologies, tools and guidelines.
- ACTION will allow anyone to design and realise a citizen science project, from the early stages of project ideation to validating and publishing the results and beyond.

ACTION

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 824603.

Citizen Science – Open Data



- There are a large community of users who are eager to use the new version of the app (coming soon).
- The app can now deliver its dng (raw) files to the backend so we will be able to retrieve the image and the metadata with a query.
- The fine tuning of the calibration for different models of cameras will be made by analysing the users feedback (citizen science).
- Yes, we would like to export this app to Android but the number of camera models is huge.
- Open Data for science ready to download by researchers (profesional and citizens)