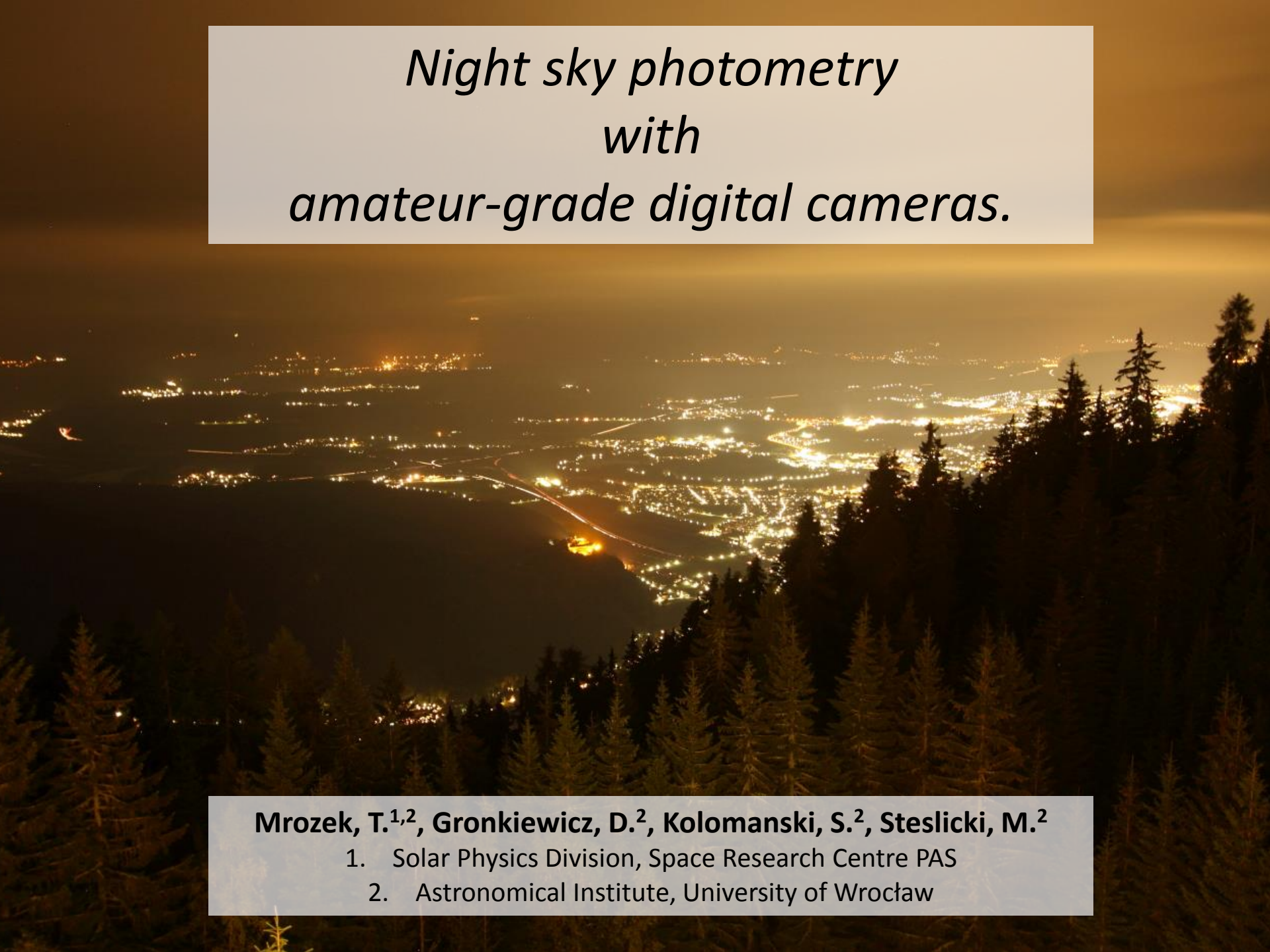
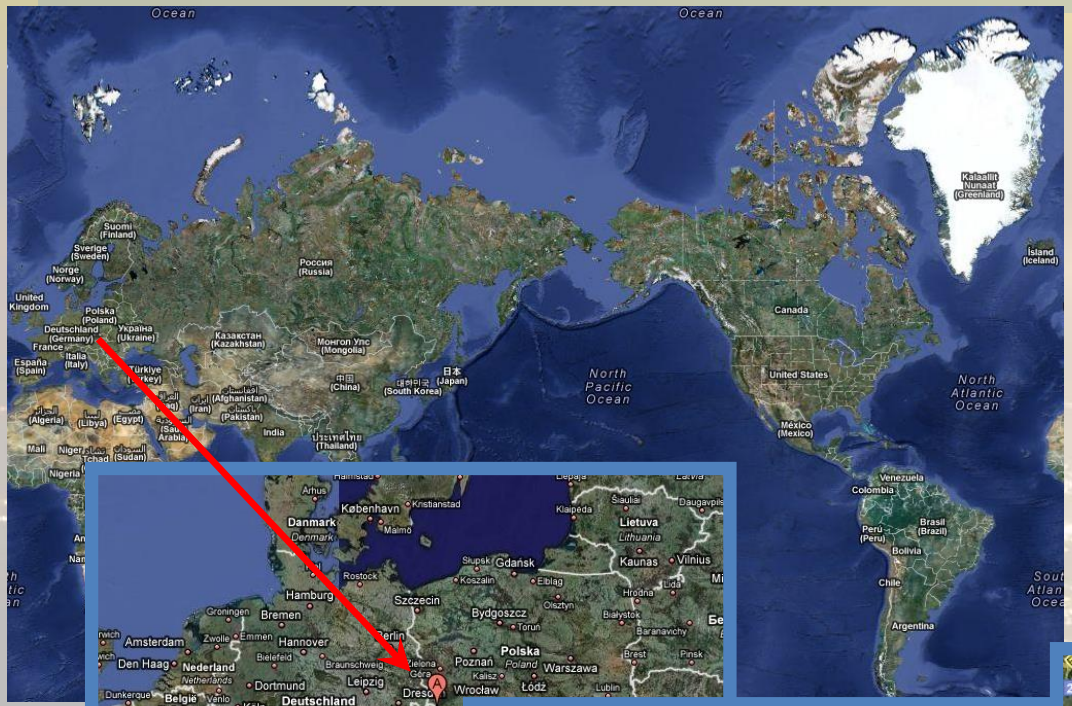
Night sky photometry with amateur-grade digital cameras.

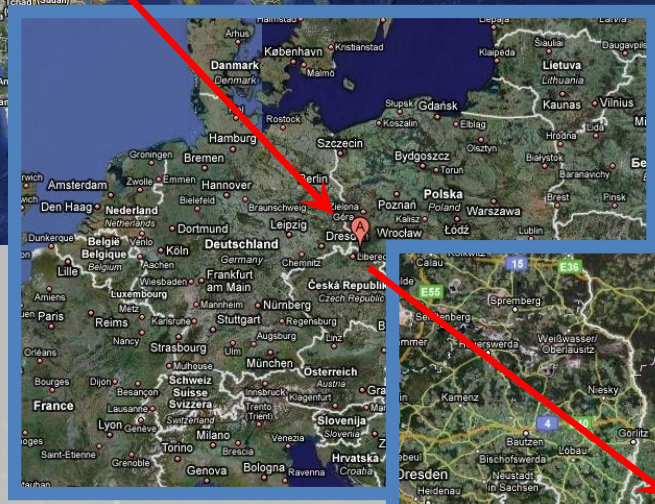


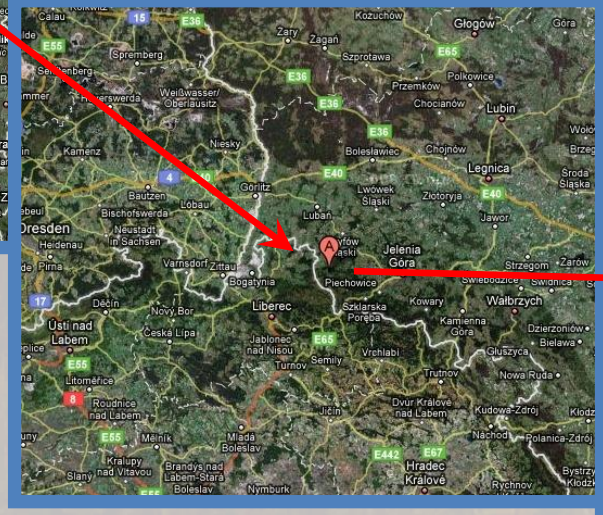
Mrozek, T.[1,2], Gronkiewicz, D.[2], Kolomanski, S.[2], Steslicki, M.[2]

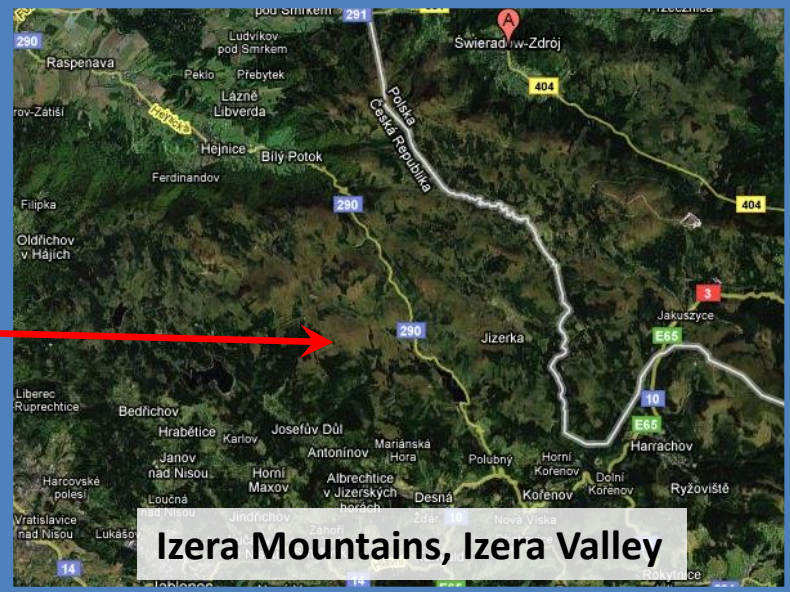
1. Solar Physics Division, Space Research Centre PAS
2. Astronomical Institute, University of Wrocław

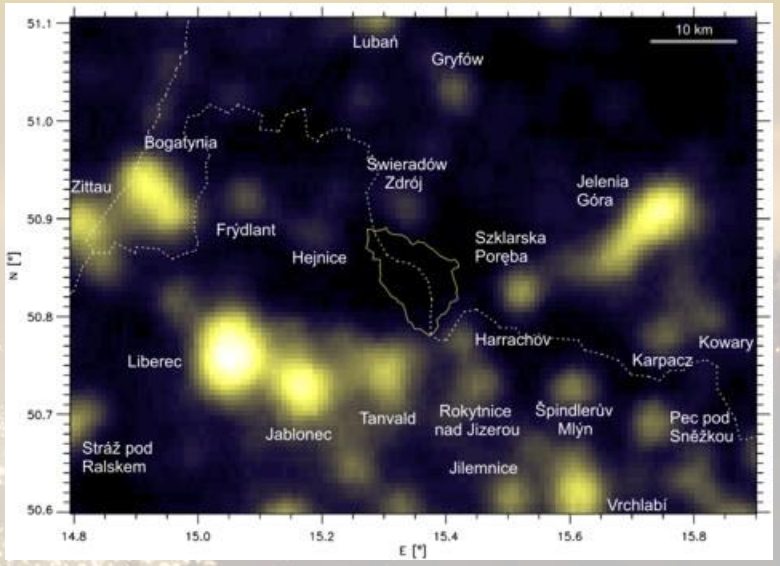
Dark sky protection & education in the Izera Mountains



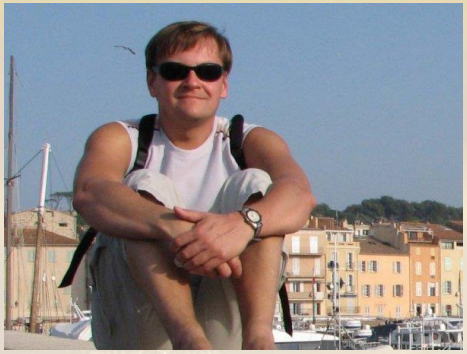








Dark sky protection & education in the Izera Mountains



WEDNESDAY, AUGUST 12, 2015

5:40 PM - 6:00 PM
Room 316B

FM2.6.07. Dark Sky Protection and Education - Izera Dark Sky Park
Arkadiusz Berlicki; Sylwester Kolomanski; Tomasz Mrozek; Grzegorz Zakowicz

THURSDAY, AUGUST 13, 2015

8:45 AM - 9:00 AM
Room 316B

Astronomy Education Under Dark Skies
Joanna C. Molenda-Zakowicz, Grzegorz Zakowicz,
Sylwester Kolomanski, Tomasz Mrozek, et al.

Need for dark sky measurements

Let's take a photo of a night sky.

Astronomical Institute UWr, 4 km from Wrocław's center

Jelcz-Laskowice (population 15k), 20 km from Wrocław's center

Białków observatory, 60 km from Wrocław's center

Method for (almost) everyone

Equipment and assumptions:

1. Camera capable to register RAW files
2. Manual exposure and focus
3. Tripod.
4. Computer with cheap/free software
5. simplicity, but still valuable measurements
6. free from detector aging effects (SQMs are calibrated only once)

VS

First measurements (February 20th, 2015 r., Białków)

Białków Observatory of Astronomical Institute, University of Wrocław (60 km from Wrocław's center)

Equipment

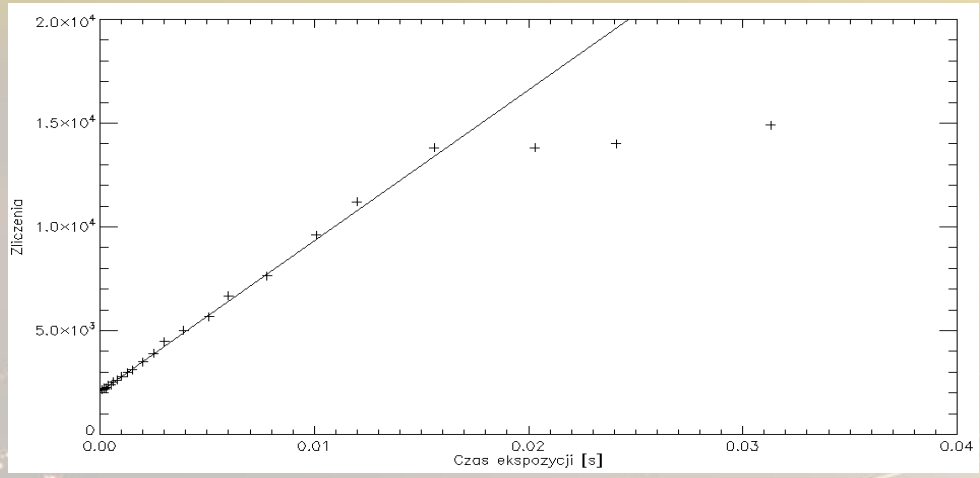
- Canon 1100D + kit lens 18-55
- Canon 450D modified + kit lens 18-55
- Canon 7D + 60 mm lens
- Nikon D90 + kit lens 18-105
- Canon Power Shot S2 IS
  (with Canon Hacker's Development Kit)
- SQM-LU
- All-sky camera

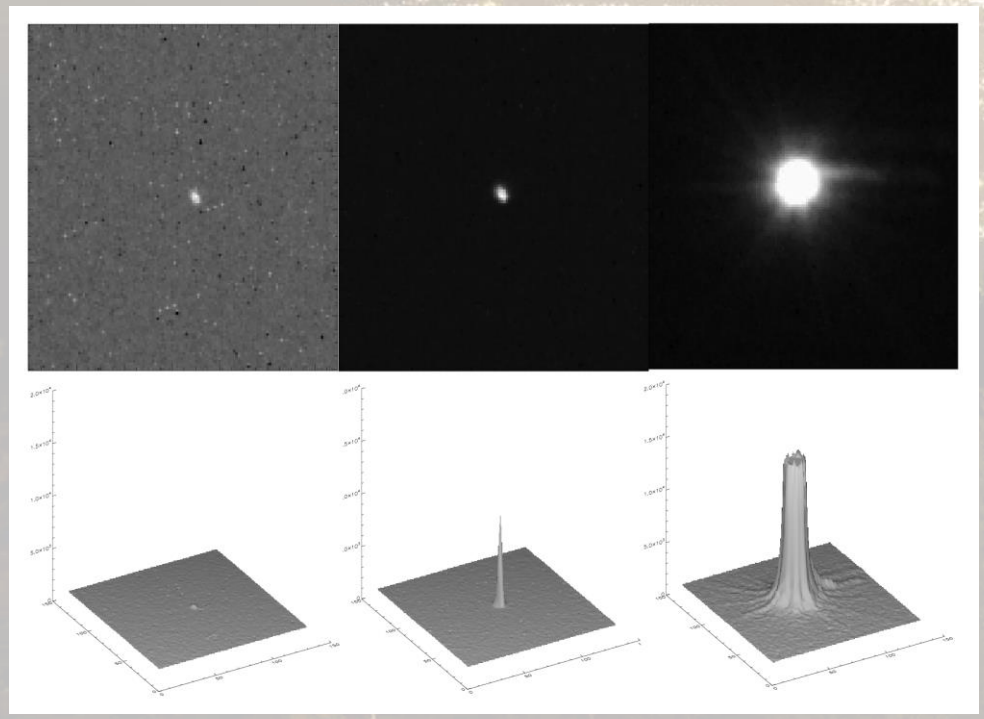
Methodology

- Estimate DN range of linear response
- Take 5-10 exposures of 5 and 20 seconds
- Take dark and flat images
- Reduce images
- Choose stars for standardization (on 5 s images)
- Calculate standardization coefficients
- Estimate instrumental background
- Calculate standard brightness of sky background
- Compare with other cameras/lenses/instruments

The methodology was tested with several groups of secondary school students, teachers, and amateur astronomers during our various astronomical meetings in the Izera Mountains.

Range of linear response





Excellent stand-alone excercise which helps to start learning how to take a picture? what is exposure time? what is saturation? How my camera works? etc.

Good starting point to learn software (we used IRIS)

Prepare artificial point source.

Take frames with various exposure times.

Plot DN against exposure time.

Estimate, roughly, level of linear response and saturation level.

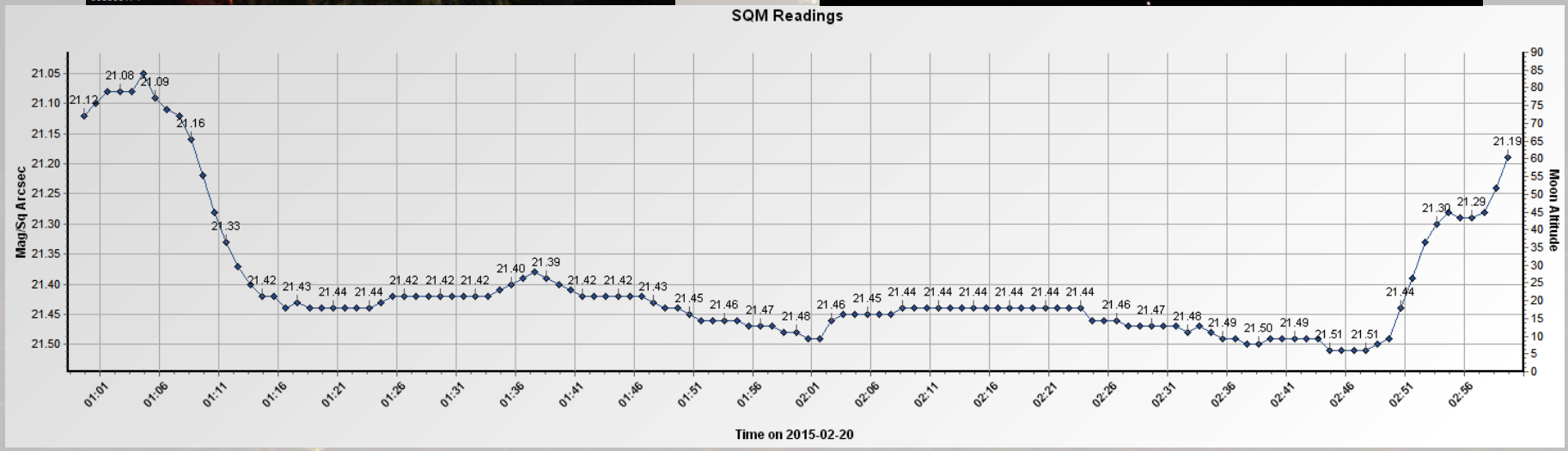
IRIS

An astronomical images processing software

http://www.astrosurf.com/buil/us/iris/iris.htm

Capturing frames.

Images were taken during excellent conditions on February 20th, 2015. All instruments were aimed to zenith.



Standardization

Astrometry.net

http://nova.astrometry.net/

With this result you can use free software (we used Stellarium) and choose several stars for standardization.

Images > IMG_7617.JPG

Submitted by anonymous (1)
on *2015-08-10T22:38:34Z*
as " IMG_7617.JPG " (Submission 727761)
under *Attribution 3.0 Unported*

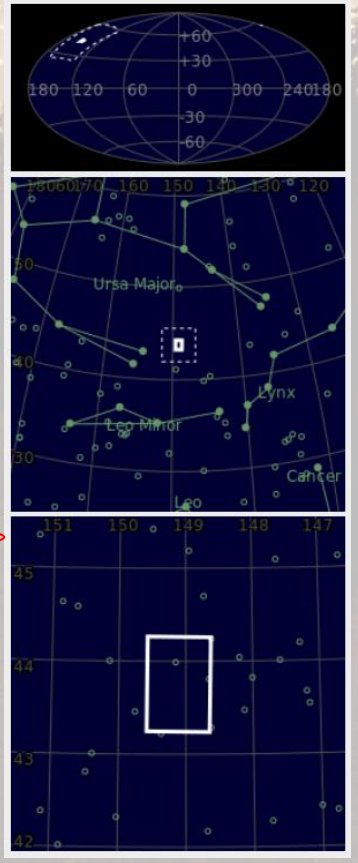
Job Status

Job 1199535:
Success

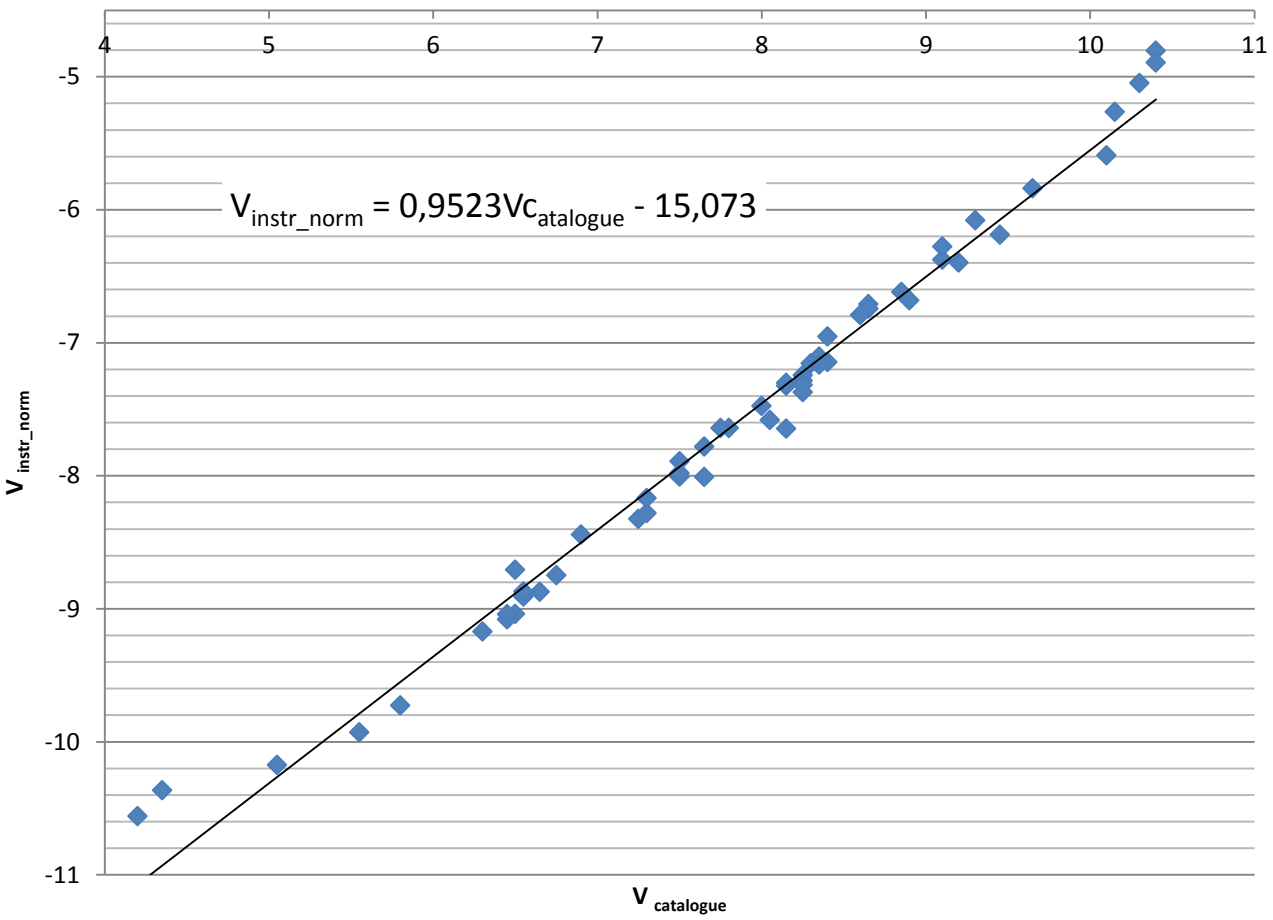
Calibration

Center (RA, Dec):	(149.106, 43.752)
Center (RA, hms):	$09^h\ 56^m\ 25.539^s$
Center (Dec, dms):	+43° 45' 06.612"
Size:	61.2 x 40.8 arcmin
Radius:	0.613 deg
Pixel scale:	3.67 arcsec/pixel
Orientation:	Up is 89.3 degrees E of N
WCS file:	wcs.fits
New FITS image:	new-image.fits
Reference stars nearby (RA,Dec table):	rdls.fits
Stars detected in your images (x,y table):	axy.fits
Correspondences between image and reference stars (table):	corr.fits
KMZ (Google Sky):	image.kmz

Nearby Images (View All)



Standardization. Inclination problem.



For estimation of sky brightness we have to extrapolate this relation by 10-12 orders of magnitude.

Even small errors in inclination may explode when extrapolated from 8mag to 21 mag.

Therefore we assume that inclination is 1 (it should be) and calculate only free parameter of linear fit as a difference between standard and instrumental brightness.

Standardization

Instrumental brightness normalized:

$$V_{inst\_norm} = -2{,}5 \times \log\left(\frac{C_{ounts}}{t_{\exp}}\right)$$

Instrumental constant:

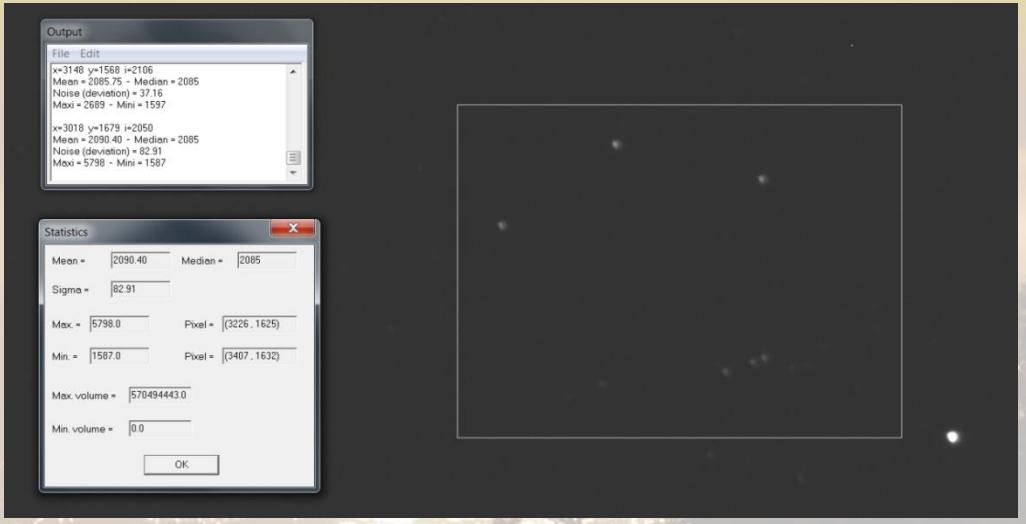
$$b = V_{cat} - V_{inst\_norm}$$

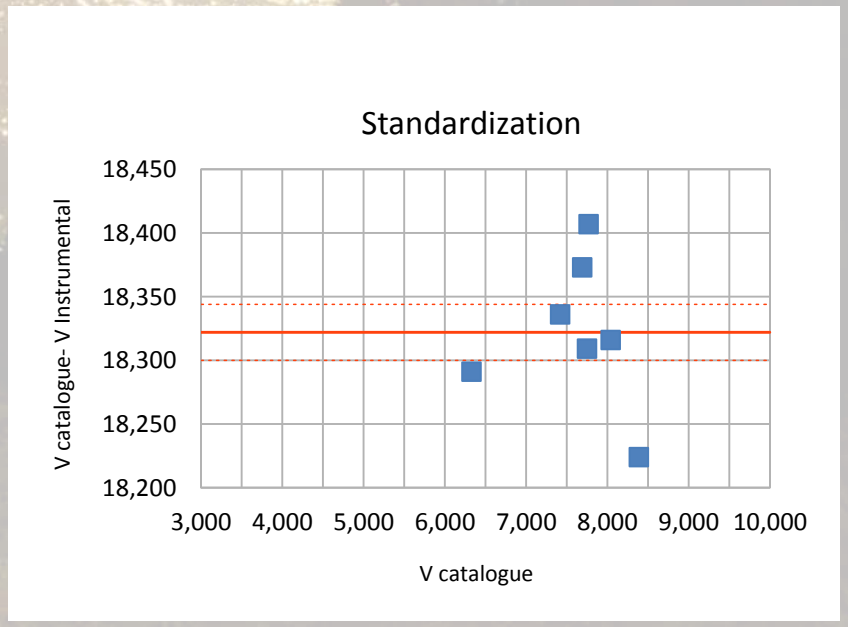
Background instrumental brightness normalized:

$$V_{bckg\_inst\_norm} = -2{,}5 \times \log\left(\frac{C_{ounts}}{t_{\exp} * S}\right)$$

Background brightness standarized:

$$V_{bckg} = V_{bckg\_instr\_norm} + b$$



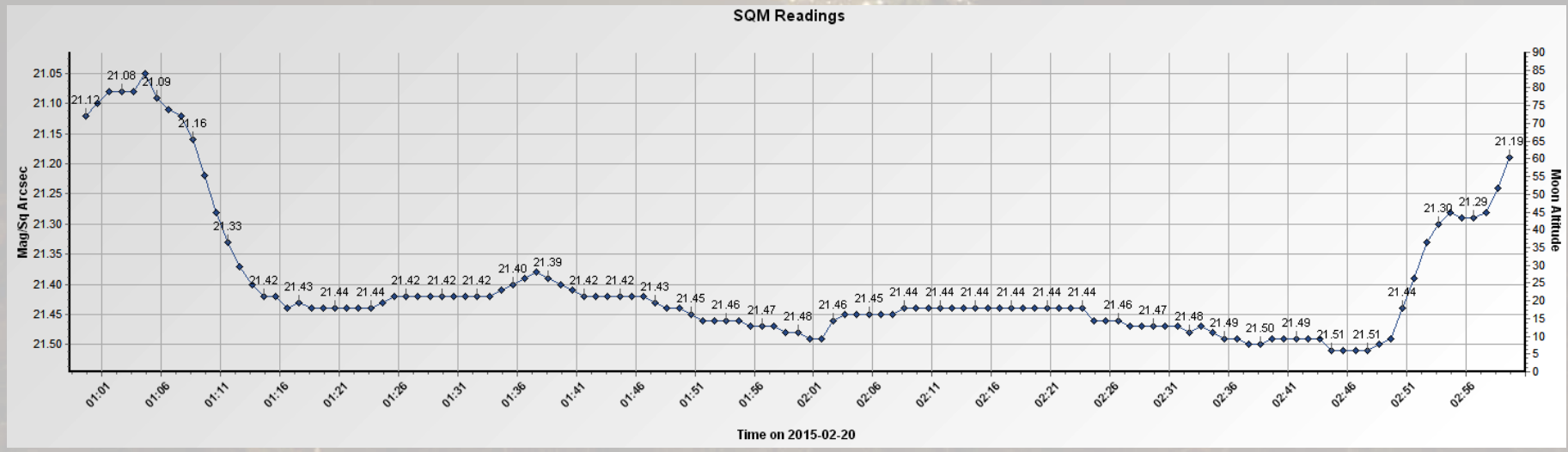


Results

camera	Sky brightness (mag/arcsec^2)
Canon 1100D	21,26 ± 0,06
Canon 450D mod.	21,11 ± 0,06
Canon 7D	21,19 ± 0,07
Nikon D90	21,17 ± 0,06
Canon S2 IS (soft. mod.)	21,03 ± 0,06
SQM	21,43 – 21,51 (± 0,2)

Acceptable consistency of results obtained with various cameras (within 0,2 mag/arcsec^2)

SQM gave systematically lower values of brightness (0,2-0,4 mag/arcsec^2)



Summary

- We developed methodology for very simple, quantitative method of night sky brightness measurements based on popular DSLR and compact cameras.
- Obtained values are similar, within errors, giving a chance that this method may be used for obtaining valuable observations from huge number of observers.
- We tested methodology with secondary school students, group of teachers, and group of amateur astronomers. This helped us to simplify method by rejecting most problematic issues without significant degradation of final result.
- The method is used for built a data base of measurements within Wygasz project (J. Molenda-Zakowicz and A. Berlicki talks), and for comarison with modified Berry model.