Night Sky Brightness Measurements: Review and Prospects

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2015-Light Pollution Theory, Modeling, and Measurements, Jovence, Quebec, CANADA
The globe at night
Measurement of Light Pollution

• Light Pollution: environmental degradation due to artificial lighting

• Effects of light pollution can be
  – "Local" (light nuisance, light trespass), often assessed from effects on ecological systems and on humans’ health; Measured by luxmeters, etc
  – "Extended" (sky glow), assessed from atmospheric and astronomical effects.

• Night sky brightness measurements include BOTH artificial sky-glow and natural components (airglow, zodiacal/star/Galactic light, etc)
Night Sky Brightness (NSB) Measurements

• Astronomical photometry
• Wide-field photometry
• Remote sensing
• Citizen science
• Dedicated NSB devices
• Night sky spectroscopy
• Others
  – Visual Photometer
  – Comets, ...
Astronomical photometry

• Photometric measurements of the night sky using optical telescope

• Equipment:
  – CCD camera (or photomultiplier tubes, PMT)
  – Telescope
  – Filters

• Advantages:
  – Photometric accuracy is very high (error $\leq \pm 0.02$ mag arcsec$^{-2}$)
  – Multiple bands measurement

• Disadvantages:
  – Highest cost (personnel, equipment)
  – Low geographical (at the observatory) & temporal (relatively few observations per nights) coverages

Patat, F. 2008, Astronomy & Astrophysics, 481, 575

- Very Large Telescope (VLT), La Silla Paranal Observatory, Chile
- Sensor: FOcal Reducer/low Dispersion Spectrograph (FORS1)
- Filters: photometric broadband Johnson-Cousins UBVRI
- Period: year 2000-2006
- Data collection: about 10,000 images from more than 650 separated nights
Flowchart:

1. Observatory
2. Telescope + Sensor
3. Imaging on object & standard star fields
4. Data pre-processing (bias, dark & flat-field)
5. Calibration
6. Standard zenith NSB
7. Color transformation equations
8. Extract NSB (Patat 2003b)
9. Color transformation coefficients
10. Aperture photometry

More details at Patat, F. 2003a, Astronomy & Astrophysics, 400, 1183
Patat, F. 2003b, Astronomy & Astrophysics, 401, 797

Methodology
Result highlights

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Note: Values are expressed in mag arcsec$^{-2}$. Columns 3 to 8 show the rms deviation, minimum and maximum brightness, number of dark-time data points, expected average contribution from the zodiacal light, and total number of data points.

- **UBVRI** NSB correlated with solar activity.
- $V$, $R$, and $I$ results show a 6-month oscillation pattern.

Zenith-corrected dark time NSB measured at Paranal
Wide-field photometry

• Photometric measurements of the night sky using wide-field light correctors
• Equipment: all-sky camera, wide-field lens (e.g., fish-eye lens), etc
• Advantages:
  – Relatively low cost (compare with traditional photometry)
  – Can be portable, i.e., larger geographic coverage
  – Collect information on directional distribution of light pollution
• Disadvantages:
  – Absolute calibration over the entire frame and over time can be a challenge
Wide-field photometry: Duriscoe et. al. (2007)


• Location: over 80 locations throughout the US
• Lens: Nikon 35 mm f/1.4, Nikon 50 mm f/1.8
• Mount: Celestron NexStar
• Sensors: Apogee AP260EP, Finger Lakes Instruments MaxCam CM9, SBIG STL 1001E, Finger Lakes Instruments IMG 1001E
• Filter: Custom Scientific Bessell V
• Period: 2001+
• Data collection: over 300 all-sky observations
Flowchart:

1. Telescope setup
2. Sky imaging & standard star fields
3. Data pre-processing (bias, dark & flat-field)
4. Aperture photometry
5. Mosaic all-sky data
6. Extract NSB (sample points evenly every 2deg)
Result highlights

• Light domes identified.
• Total light from the city sky glow higher than any permanent celestial objects except the Moon.
• City effects detected up to 100 - 170 km from the city center
Natural sky brightness Model

Duriscoe, 2013, Publications of the Astronomical Society of the Pacific, 125, 1370

- Moonless natural sky V-band brightness model
- Considered: zodiacal light, airglow, integrated starlight, diffuse galactic light
- Deduce the artificial component from all sky images

Fig. 12.—Sky brightness at Bandelier National Monument, New Mexico. From this site the light domes of several cities around the horizon are evident, as well as significant anthropogenic sky glow at the zenith (c). The airglow component in the model (a) is arbitrarily set at a moderate level.
Wide-field photometry: Rabaza (2014)

Rabaza, D. 2014, Lighting Research & Technology, 46, 5

• Location: Spain
• Lens: AF DX Fisheye-Nikon 10.5 mm f/2.8 G ED (180 deg FOV)
• Sensor: SBIG STL-11000 M
• Filters: narrow-band interference filters centered at 438.2, 527.8, 555.0, 568.4, 577.8, 598.3 and 618.0 nm
• Period: ?
• Data collection: ?
• Calibration: integrating sphere
Methodology

setup

data collection

calibration (integrating sphere, synthetic flat field)

data processing
Result highlights

• Monochromatic luminance and radiance of the sky background measured

• Color information may reveal the kind of lamps that emitted the main components of the obtrusive light detected

438.2 nm: mercury emissions (circles)

527.8 nm
Remote sensing

• Data: night-time remote-sensed data such as:
  – Operational Linescan System, Defense Meteorological Satellite System (OLD-DMSP)
  – Day-Night Band, Visible Infrared Imaging Radiometer Suite (DNB-VIIRS, Suomi National Polar-orbiting Partnership)
  – International Space Station (ISS)
  – aerial photos

• Advantages:
  – Large geographic coverage (up to global scale)

• Disadvantages:
  – Low temporal coverage
  – Low geographic resolution for sub-city analysis (DMSP)
  – Single band of observation (except ISS)
  – Absolute calibration over the large spatial coverage and over time
Remote Sensing: Cinzano et. al. (2001)

• Data: cloud-free composite of OLD-DMSP
• Scale: worldwide
• Sampled period: 28 nights during 1996-1997
• Band: converted to photometric astronomical V band at zenith
• Calibration: radiance data based on a pre-flight irradiance calibration of the OLS PMT
• Light propagation model:
  – Rayleigh scattering by molecules, Mie scattering by aerosols, atmospheric extinction along light paths and Earth curvature
Result highlights

• The World Atlas of the Sea Level Artificial Night Sky Brightness
Result highlights

• Light pollution is a global-scale problem affecting nearly every country of the world
  – the night sky appears more seriously endangered than commonly believed

• Large numbers of people have lost their dark sky
  – For more than 1/4 of the world population, the sky brightness is even greater than that measured on nights close to full moon in the best astronomical sites

• Sky quality near astronomical observatories severely degraded in less than 20 years
Remote Sensing: A. Sánchez de Miguel et. al. (2014)


• Data: OLD-DMSP
• Scale: Spain
• Study theme: relationship between the radiance received by the satellite and the energy consumption (official data from the government)
Result highlights

• Strong correlation between the radiance and energy consumption

• Derived the electricity consumption for street lighting in Spain from 1992 to 2010
  – doubled in the last 18 years in most provinces
Remote Sensing: Kuechly et. al. (2012)


- Data: mosaic image from aerial (3000 m) photography
- Spatial resolution: 1 m
- Coverage: Berlin, Germany
- Sampled period: single flight during 20:40 - 23:23 local time (UT+2) 11 September 2010
- Sensor: Finger Lakes Instruments camera (interline transfer CCD)
- Lens: Sigma 24 mm F1.8 DG
- Filters: Luminance, Red, Green, Blue
Result highlights

DMSP 2006 data
Result highlights

ISS (45m resolution)  Aerial mosaic (1m resolution)
Remote Sensing: Kyba 2015
Kyba, C. et. al. 2015, Remote Sensing, 7, 1

• Data: OLD-DMSP, DNB-VIIRS, ISS, aerial
• Locations: 6 European cities, USA

Tegel airport in Berlin, Germany

OLD-DMSP (~2.7km)  DNB-VIIRS (~750m)  aerial (~1m)
Result highlights

• City light changes dynamically over the course of the evening

ISS images of Madrid at different times of night
Result highlights

• Difference patterns in light emission in different cities

Upwelling radiance of six European cities in the VIIRS two-month composite dataset

ISS images of six European cities
Result highlights

• Different lighting sources

color difference of many of the smaller streets in the former East (orange) and West (white) in Berlin from ISS image
Citizen science

• Count the number of stars visible by naked eyes
• Equipment: eyes
• Advantages:
  – Required no special skills other than identification of constellations
  – Large geographical & temporal coverages with low cost
  – Estimate light pollution condition near city centers
  – Spread of messages of dark sky conservation
• Disadvantages:
  – Photometric error would be very large (particularly projects with visual observations)
Citizen science: Globe at Night

- Locations and data collection (2014 campaign): 20,746 observations from 103 countries / regions
- Period: since 2006
Methodology

Five Easy Star Hunting Steps:

1. Use the Globe at Night website to help find your constellation in the night sky.
2. Use the Globe at Night website to find the latitude and longitude of the location where you are making your observation.
3. Go outside more than an hour after sunset (8-10 pm local time). The Moon should not be up. Let your eyes become used to the dark for 10 minutes before your first observation.
4. Match your observation to one of 7 magnitude charts and note the amount of cloud cover.
5. Report the date, time, location (latitude/longitude), the chart you chose, and the amount of cloud cover at the time of observation. Make more observations from other locations, if possible. Compare your observation to thousands around the world!

Globe at Night 2015 Dates and Constellations

**Northern Constellations**

- **Orion**
  - January 11-20, February 9-18, March 11-20, 2015

- **Leo**
  - April 9-18, May 9-18, 2015

**Southern Constellations**

- **Orion**
  - January 11-20, February 9-18, 2015

- **Crux**
  - March 11-20, April 9-18, May 9-18, 2015
Result highlights
Result highlights
Kyba, C. et. al. 2013, Scientific Reports, 3, 1835

• Naked eye limiting magnitude strongly correlates with the observed values of emitted light measured by the DMSP (worldwide) and estimated from the World atlas of artificial skyglow (European and North America)

• Standard deviation of an individual observation at 1.2 mag arcsec$^{-2}$
Dedicated NSB measuring devices

• Semi-conductor light sensors
• Equipment: DigiLum luminance meter, Mark Light Meter, Sky Quality Meter (SQM), etc

• Advantages:
  – Balance between accuracy ($\pm 0.1 \text{ mag arcsec}^{-2}$) and cost ($\sim \text{USD 300 per unit}$)
  – Easy to use
  – High data sampling frequency (several seconds)

• Disadvantages:
  – Single band measurement
  – Lacking directional NSB information
Dedicated device: Puschnig et. al. (2014)


- Location: Vienna (one urban, one rural)
- Sensor: Sky Quality Meter - Lens Ethernet (SQM-LE)
- Period: Mar 2012–Mar 2013
- Data collection: every 7 seconds throughout the evening, more than $2 \times 10^6$ individual data points at urban Vienna
Methodology

- Sky Quality Meter – Lens Ethernet (SQM-LE)
- Gives NSB in the unit of mag arcsec$^{-2}$
- Claimed accuracy of ±0.1 mag arcsec$^{-2}$ by manufacturer

Figure source: Unihedron
Methodology

Spectral response function of SQM-LE (solid), quantum efficiency (dashed), and filter transmittance (dotted) (Cinzano 2005)

Angular response function of SQM-LE (Cinzano 2007)

FWHM ∼240nm

peak ∼540nm

FWHM ∼20°
Result highlights

- Detailed temporal variations of NSB
  - Curfews at 11pm and mid-night, thunderstorms, firework
- Effects of NSB vs cloud amount and moonlight identified

moonlight impacts on rural NSB observations
Dedicated device: Feng et. al. (2014)

Feng et. al. 2014, Geography Teaching, 4, 61 (in Chinese)

• Astronomy club of a local high school
• Location: over 10 locations in Wuxi, Jiangsu province, China
• Sensor: 9 SQM-L
• Data collection: NSB in different locations, change in NSB from zenith distance, etc
Result highlights

Strong positive correlation between NSB and distance from city center

Increase in NSB with decreasing angle off horizon
Dedicated device: Pun et. al. (2014)


• The Hong Kong Night Sky Monitoring Network (NSN)
• Coverage: 18 locations in Hong Kong (10 urban, 6 rural, 2 not-classified)
• Sensor: SQM-LE
• Period: May 2010 – now
• Data collection: every 1 to 5 minutes throughout the evening, 4.6 million data points reported
• Live data display: (1) project webpage http://nightsky.physics.hku.hk/; 2 (weather agency) http://www.hko.gov.hk/gts/astro_luna/
Methodology

Data transfer through 3G network, no fixed internet connection required
Methodology

Image courtesy of Image Science and Analysis Laboratory, NASA-Johnson Space Center, The Gateway to Astronaut Photography of Earth
Result highlights
- NSB depends on location
Result highlights
- NSB depends on time

Graph showing the nightly average NSB (mag arcsec²) for different locations:
- TST (urban)
- WTS (urban)
- TSW (urban)
- GFS (not-classified, airport)
- iObs (rural)
- AP (rural)
Result highlights
- moonlight impacts on rural NSB observations
Night Sky Spectroscopy

• Equipment:
  – Spectrograph
  – Telescope (optional)
  – CCD camera

• Advantages:
  – Identify the sources of light pollution (type of lighting, e.g., high pressure sodium lamps, mercury lamps, etc) by studying features detected in the sky spectra

• Disadvantages:
  – No single “standard” spectrum of lamp
  – Absolute calibration a challenge (e.g., need spectrophotometric standard stars)
Patat, F. 2003a, Astronomy & Astrophysics, 400, 1183

• Location: Very Large Telescope (VLT), La Silla Paranal Observatory, Chile
• Telescope: 8.2m ESO Antu/ Melipal telescope
• Sensor: FOcal Reducer/low Dispersion Spectrograph (FORS1)
• Slit and grism: 1” long slit and 150I grism
• Period: 25 Feb 2001 (moonless)
• Data collection: high signal-to-noise, flux calibrated night sky spectrum
Result highlights

- Light-polluted lines e.g., Hg I (3650, 3663, 4047, 4078, 4358 and 5461 Å) and NaI (4978, 4983, 5149 and 5153 Å) very weak in the Paranal’s sky spectra.

Fig. 1. Night sky spectrum obtained at Paranal on February 25, 2001 02:38UT in the spectral region covered by B, V, R and I passbands (from top to bottom). The original FORS1 1800 s frame was taken at 1.42 airmasses with a long slit of 1” and grism 150I, which provide a resolution of about 22 Å (FWHM). The dashed lines indicate the passband response curves. Flux calibration was achieved using the spectrophotometric standard star Feige 56 (Hamuy et al. 1992) observed during the same night. The absence of an order sorting filter probably causes some second order overlap at wavelengths redder than 6600 Å.
Night sky spectroscopy: Puschnig et. al. (2014)

- Location: Vienna University Observatory
- Spectrograph: SBIG DSS-7 + ST7
- Telescope: 0.8 m in diameter
- Period: 1 February 2012
- Data collection: point the telescope to the south or to the south-east (i.e. towards the city center of Vienna) at an elevation of ~45deg, 300s integration time
Result highlights

• Strong spectral lines detected at 546 nm (fluorescent lamps, common in residential areas) and 611 nm (high pressure sodium, use in streetlamps and highway lamps)
Others - Cometary (Ściężor 2013)

• The method is based on measurements of the surface brightness of the faintest diffuse objects visible in the sky.
• DC value: describes the degree of condensation of the comet on the sky background
  – DC = 0 indicates totally diffuse; DC = 9 means stellar
• surface brightness of the weakest comet (DC=0, 1 or 2) can be used as an approximate value of NSB
• Advantages:
  – If archival observations of comets are available, NSB in the past can be traced back to determine long-term changes in NSB.
• Disadvantages:
  – Results depends on observer skills and experiences.
Others - Cometary (Ściężor 2013)

• Location: several locations in Poland
• Period: 1994 - 2009
• Comet observations: 451 comet observations (comets dimmer than 7 mag)

• Result highlights:
  – no change in NSB in ecologically clean areas
  – clear increase in light pollution for sites located on the border of heavily light-polluted and less light-polluted areas
  – clear decrease in light pollution for sites had fall in industry
# Night Sky Brightness Measurements

<table>
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<tr>
<th>Application</th>
<th>Geographic coverage</th>
<th>Temporal coverage</th>
<th>Cost</th>
<th>Accuracy</th>
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<td>Spread light pollution messages, cheap, large coverage</td>
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<td>Obtain spectral information</td>
<td>Calibration challenge</td>
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Measurement of Light Pollution: Prospects

• Combining features of different methods for better results
• Take advantage of the dedications of citizens beyond communities of amateur astronomers
• Take advantage of the widespread technology available
• Long-term spectroscopic (at least multi-band) monitoring of night sky at urban locations
• Connecting the remote-sensing data and the ground-based night sky measurements (looking down vs looking up)
Dedicated device + Multi-band observation


• Results highlights:
  – More blue light when the night sky is clear (Spoelstra, 2014)
  – Red is the new black (Kyba et. al. 2012)
Citizen science + converted-NSB meter: Dark Sky Meter IYL 2015 Edition (iPhone app)

**DARK SKY METER**

**STEP 1**

Cover camera and press 1

**1 DARK**

**RESULTS**

This sky is 1700 times brighter (than a natural dark sky)

Inner city sky
Sky is brilliantly lit, with many stars forming constellations invisible. Only objects to provide fairly pleasant views are the Moon, the planets, and a few star clusters.

Tap to enter conditions

Submit (optional)
Citizen science + Wide-field photometry: Hoshizora Kodan (the alliance of starlight distributors)

See more: http://dcdock.kodan.jp/?lang=en

- Location: over 2,000 points in Japan
- Equipment: commercial Digital Single Lens Reflector camera (DSLR)
- Both automatic-fixed and temporary set up
- Filters: N/A (RGB in sensor)
- Period: 2008+
We recommend digital still camera with RAW format which released after 2008.

Canon
EOS 1D Mark IV, EOS 1D X, EOS 5D Mark II*, EOS 5D Mark II(sRAW)*, EOS 5D Mark III, EOS 5Ds, EOS 5Ds R, EOS 6D*, EOS 6D(sRAW), EOS 60D*, EOS 60D(sRAW), EOS 60Da, EOS 7D*, EOS 7D Mark II, EOS 50D*, EOS 60D, EOS 70D, EOS 8000D, EOS Kiss F*, EOS Kiss X2*, EOS Kiss X3*, EOS Kiss X4*, EOS Kiss X5*, EOS Kiss X50*, EOS Kiss X6i*, EOS Kiss X7i, EOS Kiss X7, EOS Kiss X70, EOS Kiss X8i, EOS M, EOS M2, EOS M3

NIKON
D3X, D3s, D4, D4s, Df, D300S*, D700*, D800*, D800E, D600*, D600(DX), D610, D810, D750, D60*, D90*, D3000, D3100, D3200, D3300, D5000*, D5100*, D5200, D5300, D5500, D7000*, D7100, D7200, 1 V1, 1 V2, 1 V3, 1 J1*, 1 J2, 1 J3, 1 J4, 1 J5, 1 S1, 1 S2, 1 AW1

OLYMPUS
E-5*, E-30, E-420*, E-520, E-620, E-P1*, E-P2, E-P3, E-P5, E-PL1, E-PL1s, E-PL2, E-PL3, E-PL5, E-PL6, E-PL7, E-PM1, E-PM2, E-M5*, E-M1, E-M10, E-M5 Mark II

Panasonic
DMC-G1*, DMC-GH1, DMC-GF1, DMC-G2, DMC-G10, DMC-GH2*, DMC-GF2, DMC-G3*, DMC-GF3, DMC-GX1, DMC-GF5, DMC-G5, DMC-GH3, DMC-GF6, DMC-G6, DMC-GX7, DMC-GM1, DMC-GH4, DMC-GM1s, DMC-GM5

PENTAX
K200D*, K20D*, K-m, K-7, K-x, K-r*, K-5*, K-30, K-5 II, K-5 II s, K-50, K-3, Q, Q10, Q7, K-01*

SONY

RICOH
GXR A12*

*Brightness with quick measurement will shown after posting data.
Methodology

- camera setup (automated) OR camera setup (manual)
- zenith sky imaging using standard parameters
- upload RAW image to an online interface
- NSB extraction (auto)
• 2011 March 11 earthquake leads to 40% lower night-sky brightness at 20:00 in Tokyo compared with the brightness during Feb-2011.

• A consequence of power saving in the area.
The Global at Night Sky Brightness Monitoring Network (GaN-MN) globeatnight-network.org

- Co-organizers:
  - Office of Astronomy Outreach, International Astronomy Union (IAU)
  - National Astronomical Observatory of Japan
  - The University of Hong Kong

- Endorsed by the IAU Executive Committee Working Group for the International Year of Light 2015 as a major Cosmic Light program
  - Expand the sky brightness monitoring network (NSN) worldwide
  - In the award letter, “Suggestions were to “coordinate ... with others who are pursuing the educational aspect in other regions.”
The Global at Night Sky Brightness Monitoring Network (GaN-MN)

• Project aims:
  – Standardized night sky measurement method for worldwide research on light pollution
  – highlight the negative environmental impacts of abusive artificial lighting for the general public and policy makers
  – sustain light pollution public education and promote public engagement by live worldwide night sky brightness data and night sky measuring programs
The Global at Night Sky Brightness Monitoring Network (GaN-MN)

• Methodology and highlights:
  – Standardized observing method:
    • SQM-LE
      – Reasonable cost and sturdy
    • Standard Unihedron housing
      – reduce inconsistency in optical window attenuation
    • 30 seconds sampling interval
    • Standardized calibration scheme
The Global at Night Sky Brightness Monitoring Network (GaN-MN)

• Methodology and highlights:
  – Data
    • Live display of NSB on Google Maps
    • Sharing of data archive among stations
  – Easy to join
    • Materials needed: SQM-LE, housing, internet connection (minimal configuration), power supply, mounting
    • Minimal maintenance except troubleshooting on power or network sometime
The Global at Night Sky Brightness Monitoring Network (GaN-MN)

- Current stations:

<table>
<thead>
<tr>
<th>Organization</th>
<th>Country /region</th>
<th>Operational date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taipei Astronomical Museum (TAM)</td>
<td>Taipei, Taiwan</td>
<td>2014-11-19</td>
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<tr>
<td>National Astronomical Observatory of Japan (NAOJ)</td>
<td>Tokyo, Japan</td>
<td>2014-12-19</td>
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<tr>
<td>The University of Hong Kong (HKU)</td>
<td>Hong Kong</td>
<td>2014-12-26</td>
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<tr>
<td>National Tsing Hua University (NTHU)</td>
<td>Taiwan</td>
<td>2014-12-30</td>
</tr>
<tr>
<td>Chungbuk National University Observatory (CNUO)</td>
<td>South Korea</td>
<td>2015-01-27</td>
</tr>
<tr>
<td>Yeongyang Firefly Astronomical Observatory (YFAO)</td>
<td>South Korea</td>
<td>2015-01-24</td>
</tr>
<tr>
<td>Lulin Observatory (LUO)</td>
<td>Taiwan</td>
<td>2015-03-27</td>
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<tr>
<td>Ho Koon Nature Education cum Astronomical Centre (HKn)</td>
<td>Hong Kong</td>
<td>2015-04-18</td>
</tr>
</tbody>
</table>
The Global at Night Sky Brightness Monitoring Network (GaN-MN)

• Stations under planning (more are coming!):

<table>
<thead>
<tr>
<th>Organization</th>
<th>Country /region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korean Astronomy and Space Science Institute (KASI) (x10 purchased)</td>
<td>South Korea</td>
</tr>
<tr>
<td>National Tsing Hua University (~ 6 – 8)</td>
<td>Taiwan</td>
</tr>
<tr>
<td>National University of Mongolia</td>
<td>Ulan Bator, Mongolia</td>
</tr>
<tr>
<td>Xinglong Observing Station of National Astronomical Observatories, Chinese Academy of Science</td>
<td>Beijing, China</td>
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<tr>
<td>Tianyi Astronomical Society, Jiangsu Tianyi High School (x10)</td>
<td>Wuxi, China</td>
</tr>
<tr>
<td>Regulus SpaceTech/Science Education Institute</td>
<td>Manila, Philippines</td>
</tr>
<tr>
<td>Nepal Sanskrit University</td>
<td>Kathmandu, Nepal</td>
</tr>
<tr>
<td>The Story of Light Festival, A project for IYL2015</td>
<td>Mumbai, India</td>
</tr>
</tbody>
</table>
The Global at Night Sky Brightness Monitoring Network (GaN-MN)
The Global at Night Sky Brightness Monitoring Network (GaN-MN)

• Easy to join in the effort

• All you need are:
  – A working SQM-LE with the standard Housing from Unihedron
  – Power supply and internet connection

• Benefits:
  – Present your results real-time to the world
  – Gain access to light pollution measurements from around the world
  – Let’s fight light pollution together!
Please join us!

For more information on the Globe at Night Sky Brightness Monitoring Network (GaN-MN), please visit globeatnight-network.org

Or Email us at: socw@connect.hku.hk, or outreach@iau.org
A big section of the general public cares about light pollution (if properly informed).

- Organized a Light Pollution Research Competition in Hong Kong in 2014
- Middle school students spending multiple nights taking over 100 data points going all around the city using public transportation.