

- Date: 2 - 3 May 2016
- Place: SI-4 415, Chungbuk National University

International Workshop on Night Sky Brightness Measurements



- **Date:** 2 - 3 May 2016
- **Place:** SI-4 415, Chungbuk National University

International Workshop on Night Sky Brightness Measurements

10:30 - 11:00 Registration

Session I : Night Sky Brightness General

Chair: Chun-Hwey Kim (CBNU)

- 11:00 - 11:30 Jason PUN (Universtiy of Hong Kong, Hong Kong)
Project Background of the Globe at Night - Sky Brightness Monitoring Network
- 11:30 - 11:45 Jerzy M. Kreiner (Pedagogical University of Cracow, Poland)
Night Sky Condition of Mt. Suhora Observatory in Poland
- 11:45 - 12:00 Bo Kyung Kwon (Kwangjin astronomical observatory, Korea)
Development of the Public Outreach Program concerning Night Sky Brightness

12:00 - 14:00 lunch

Session II : Measurements of the Night Sky Brightness

Yonggi Kim (CBNU)

- 14:00 - 14:30 Jason PUN (University of Hong Kong, Hong Kong)
Performance and Results from the Globe at Night - Sky Brightness Monitoring Network
- 14:30 - 14:45 Hong-Kyu Moon (KASI, Korea)
The Heritage of IYA2009 Korean National Node: Nation-wide GaN Network
- 14:45 - 15:00 Seo-gu Lee (KASI, Korea)
Ten Years of KASI's Activities on Dark Skies Awareness
- 15:00 - 15:15 Yong Sun Lee (Daejeon Astronomical, Korea)
Measurement of the Korean Night Sky Brightness using SQM
- 15:15 - 15:30 Joh-Na Yoon (Chungbuk National University, Korea)
Accuracy analysis of SQM with SkyCCD data of CBNU observatory

15:30 - 15:40 Coffee break

Session III : SQM User Workshop

Chair: Jason PUN (Universtiy of Hong Kong, Hong Kong)

- 15:40 - 16:10 Chu Wing SO (Universtiy of Hong Kong, Hong Kong)
Data collection concerns of the Globe at Night - Sky Brightness Monitoring Network
- 16:10 - 18:00 participants of the korean SQM users
free discussions about using SQM

18:00 - 21:30 Banquet

Date: 3 May 2016

Further Discussion for collaboration about Globe at Night-Monitoring Network



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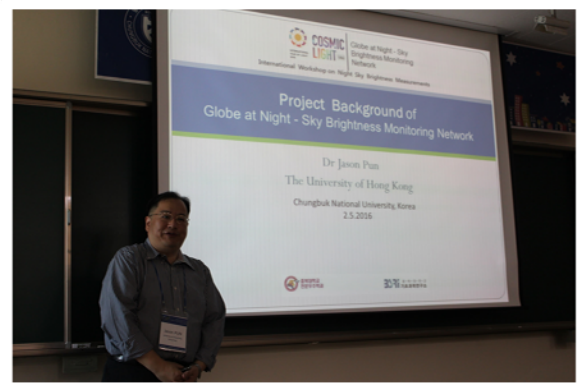
May 2~3, 2016 Chungbuk National University, Korea



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Brightness Monitoring
Network

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Project Background of Globe at Night - Sky Brightness Monitoring Network

Dr Jason Pun

The University of Hong Kong

Chungbuk National University, Korea

2.5.2016



The Earth at Night: the world illuminated



Credit: NASA Earth Observatory/NOAA NGDC

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The Earth at Night (2012)



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Credit: NASA Earth Observatory/NOAA NGDC

The Earth at Night – Korea (2014)



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Credit: Science and Analysis Laboratory, NASA-Johnson Space Center, The Gateway to Astronaut Photography of Earth
<http://earthobservatory.nasa.gov/IOTD/view.php?id=83182>

The Earth at Night – Korea (2014)



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Credit: Science and Analysis Laboratory, NASA-Johnson Space Center, The Gateway to Astronaut Photography of Earth
<http://earthobservatory.nasa.gov/IOTD/view.php?id=83182>

The Earth at Night – Seoul서울시(2014)



6

Credit: Science and Analysis Laboratory, NASA-Johnson Space Center, The Gateway to Astronaut Photography of Earth

The Earth at Night – Seoul서울시(Apr 2016)



7

Credit: Science and Analysis Laboratory, NASA-Johnson Space Center, The Gateway to Astronaut Photography of Earth

The Earth at Night – Busan부산시(2012)



8

Credit: Science and Analysis Laboratory, NASA-Johnson Space Center, The Gateway to Astronaut Photography of Earth

The Earth at Night - Jeju 제주도(2011)



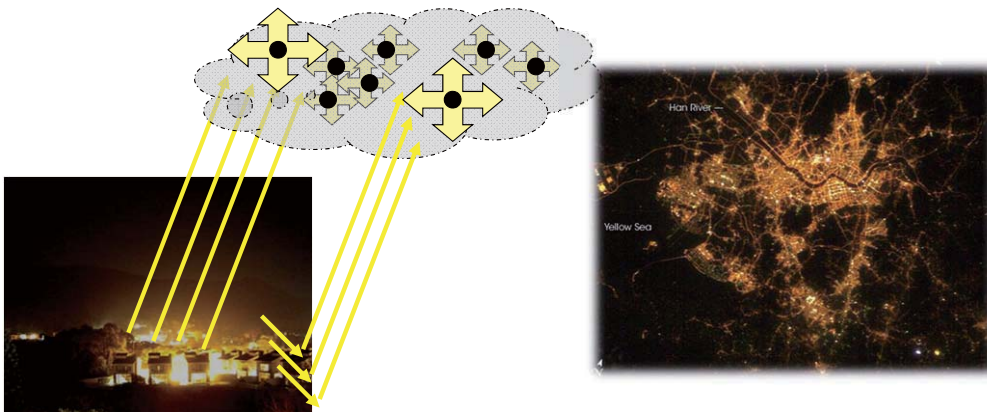
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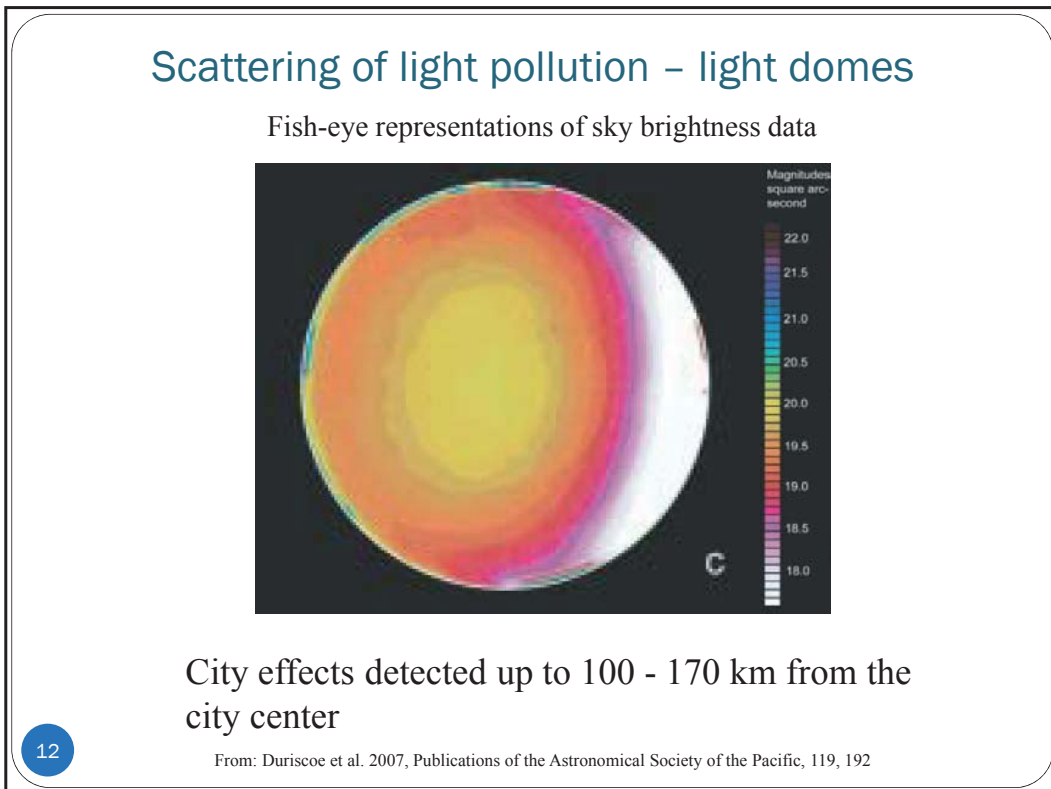
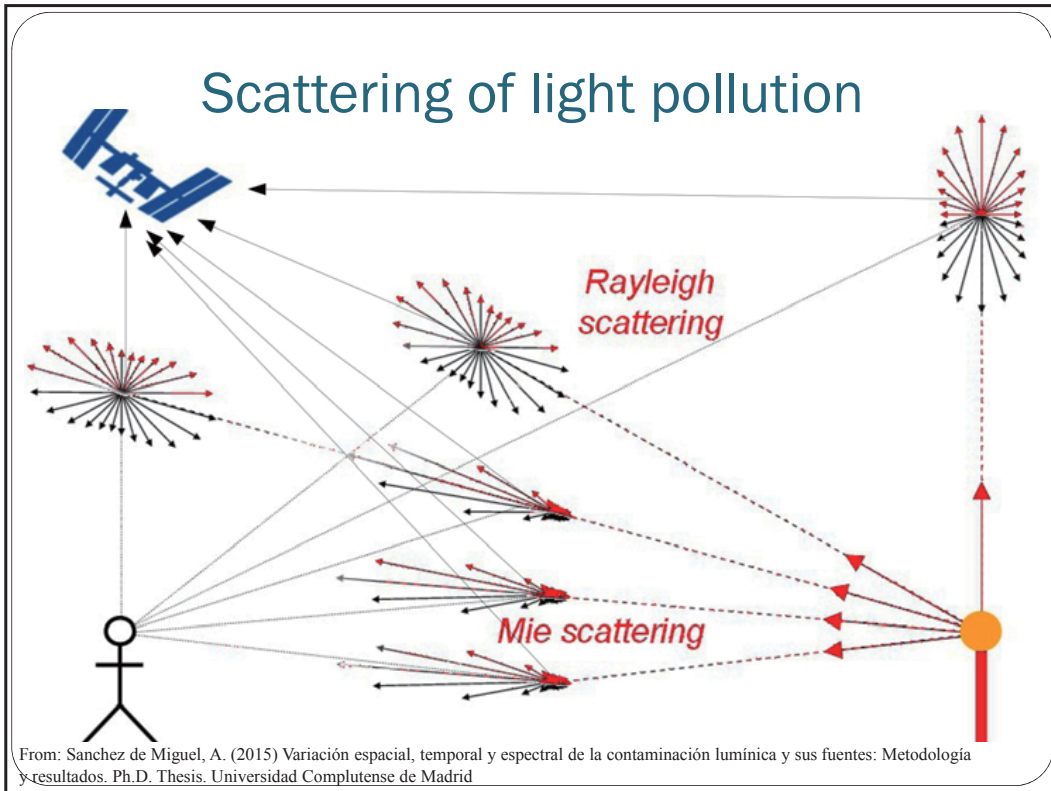
ISS027E014800

Credit: Science and Analysis Laboratory, NASA-Johnson Space Center, The Gateway to Astronaut Photography of Earth

Light Pollution

- Wasteful light emitted upwards directly by or reflected from artificial sources being scattered by aerosol (cloud, fog), or pollutants like suspended particulates in the atmosphere.





Light pollution

- Light pollution:
 - Uses of outdoor lighting: safety, recreation, advertising, decorative, etc
 - Types of lighting: incandescent lamp, fluorescent (Hg), high/low pressure sodium (Na), metal halide, mercury vapor (Hg), LED, etc
 - Environmental degradation: improper uses and abuses of artificial outdoor lighting

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Adverse effects of light pollution

- **Light Pollution:** environmental degradation due to artificial lighting
- **Health:** light trespass, light nuisance
- **Environmental:** nocturnal species, unbalance ecological systems
- **Astronomical:** skyglow / “overglow” from urban lighting
- **Energy:** light not targeted at your eyes → wasted energy

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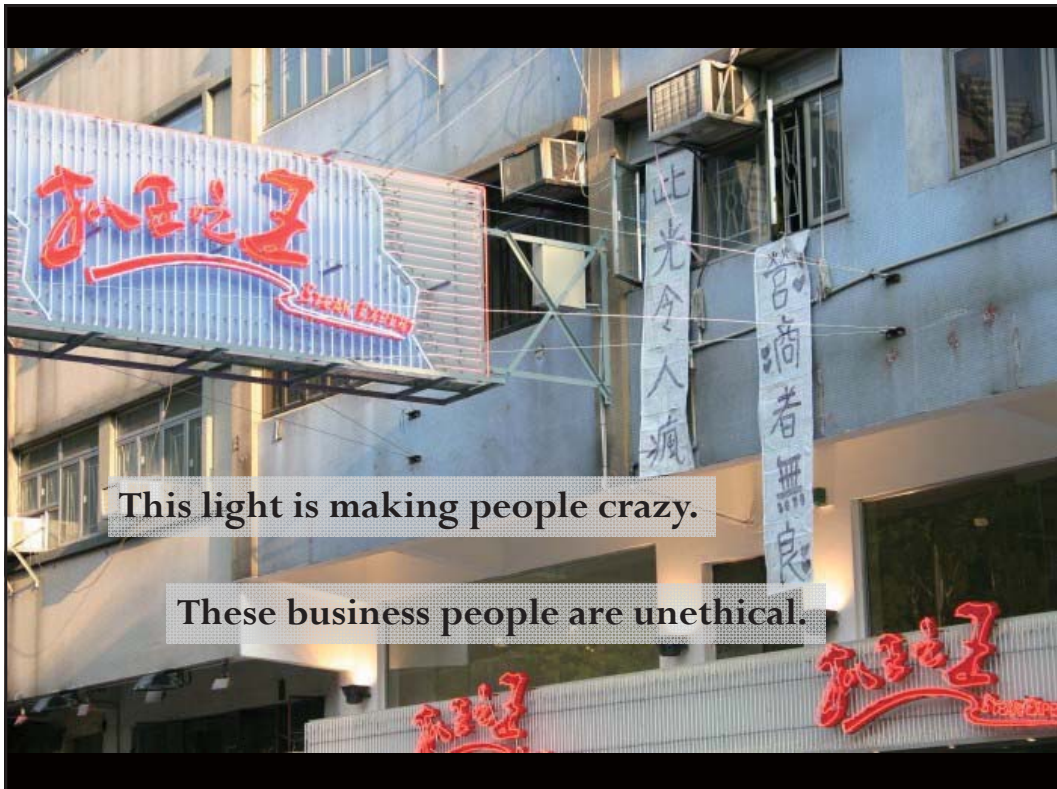
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Adverse Effects of Light Pollution: Health and Environmental



This light is making people crazy.

These business people are unethical.



Light pollution and Night Sky Brightness (NSB)

- Sky glow
 - Scattering of artificial light by cloud, aerosol, and suspended particulates in the atmosphere
 - Spreading light pollution effects to greater distance
 - Decreasing the brightness contrast of night sky
- NSB:
 - **Measured light intensity of the zenith sky at night**
 - Combination of the scattered light from artificial lighting sources and natural emissions (airglow, zodiacal/star/Galactic light, etc)

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Night Sky Brightness (NSB)

- Artificial lighting:
 - Follow routine pattern of operations nightly
 - Vary according to land utilization, population, etc
 - Scattered city light from cloud
- Natural emissions:
 - Moonlight: major natural light source
 - Low in intensity: airglow (emissions from atoms and molecules ionized by solar radiation), integrated starlight, diffuse galactic light, extragalactic background light, etc

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Measuring NSB

1. Astronomical photometry

- Traditional way: telescope + CCD sensor
- NSB is estimated by brightness of star-free regions on CCD images
- **Advantages:**
 - Small photometric error ($\leq \pm 0.1$ mag arcsec⁻²)
 - Multiple bands measurement
 - Wide range of field-of-view
- **Disadvantages:**
 - Highest cost (personnel, equipment)
 - Low geographical (at the observatory) & temporal (relatively few observations per nights) coverages

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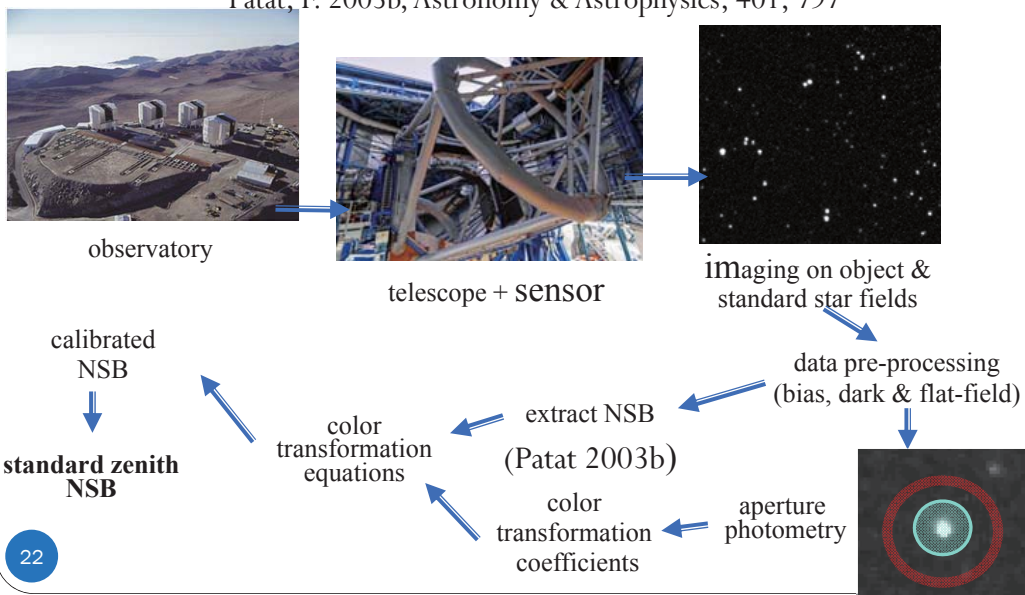


Methodology

Patat, F. 2003a, Astronomy & Astrophysics, 400, 1183

Patat, F. 2003b, Astronomy & Astrophysics, 401, 797

Flowchart:



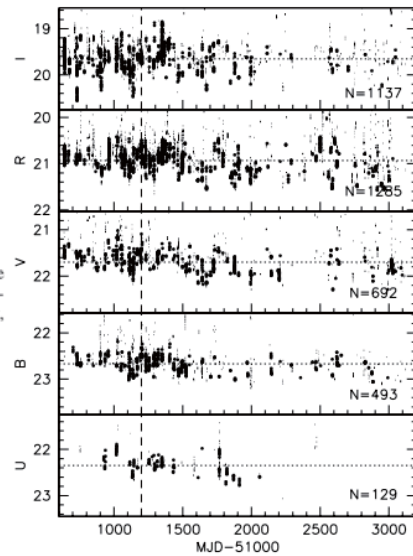
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Result highlights

Filter	Sky Br.	σ	Min	Max	N_{dark}	Δm_{ZL}	N_{tot}
U	22.35	0.19	21.89	22.78	129	0.20	264
B	22.67	0.16	22.19	23.02	493	0.28	1400
V	21.71	0.24	21.02	22.30	692	0.20	1836
R	20.93	0.24	20.42	21.56	1285	0.16	3931
I	19.65	0.28	18.85	20.56	1137	0.07	3001
Total					3736		10432

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

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Measuring NSB

2. Night-time remote sensing data:

- 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 by aircrafts
- **Advantages:**
 - Identify sources of light pollution
 - Large geographic coverage (from regional to global scale)
- **Disadvantages:**
 - Low temporal coverage
 - Challenging absolute/relative calibration over the large spatial coverage and over time

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Remote Sensing: A. Sánchez de Miguel et. al.

(2014)

A. Sánchez de Miguel et. al. 2014, Journal of Quantitative Spectroscopy & Radiative Transfer , 139, 109

- Data: OLD-DMSP
- Scale: Spain
- Sampled period & calibrations: radiance calibrated (1996–1997, 2006), non-calibrated (1992-2010)
- Study theme: relationship between the radiance received by the satellite and the energy consumption (official data from the government)

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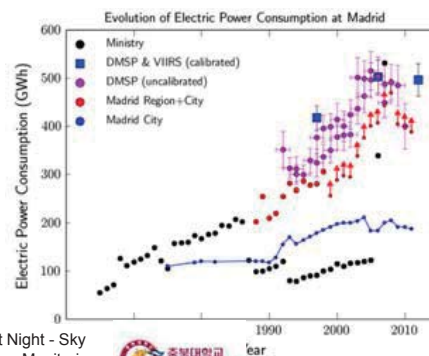
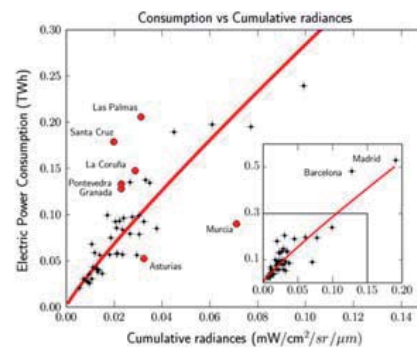
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ESRI

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



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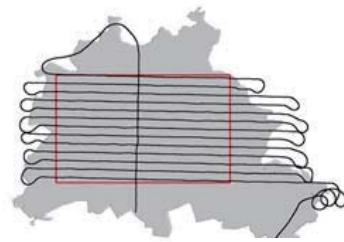
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Remote Sensing: Kuechly et. al. (2012)

Kuechly, A. U. et. al. 2012, Remote Sensing of Environment, 126, 39

- 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



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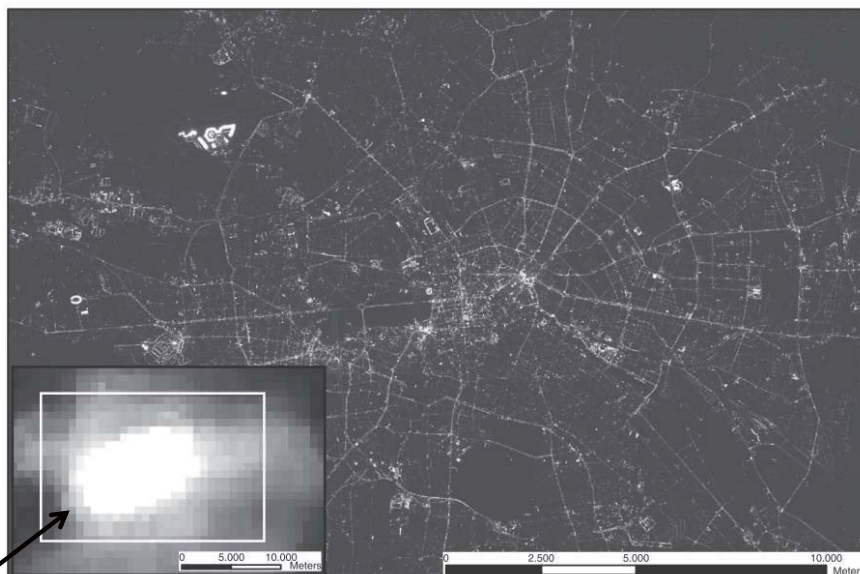
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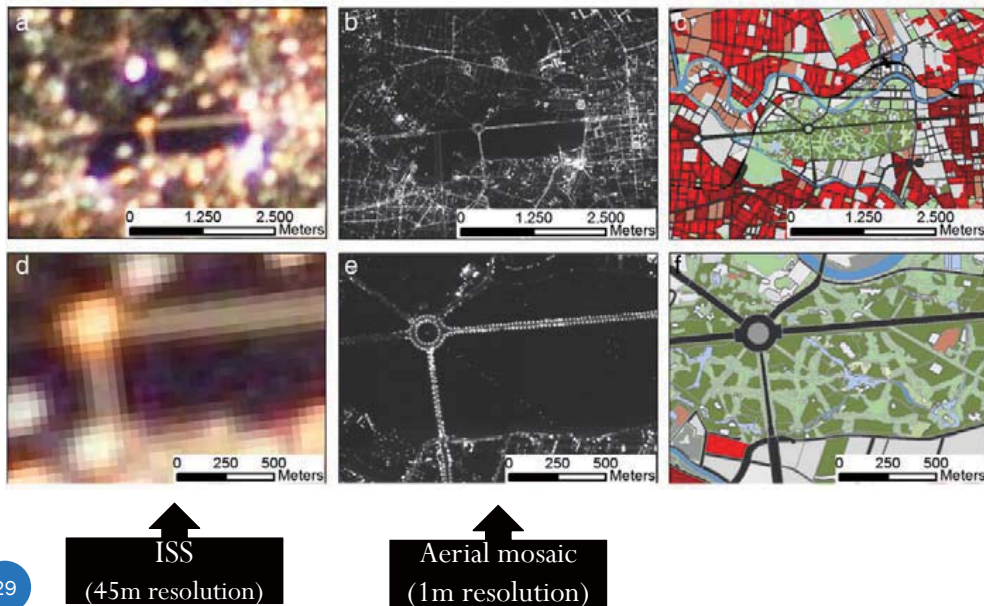
Result highlights



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DMSP 2006 data

Result highlights

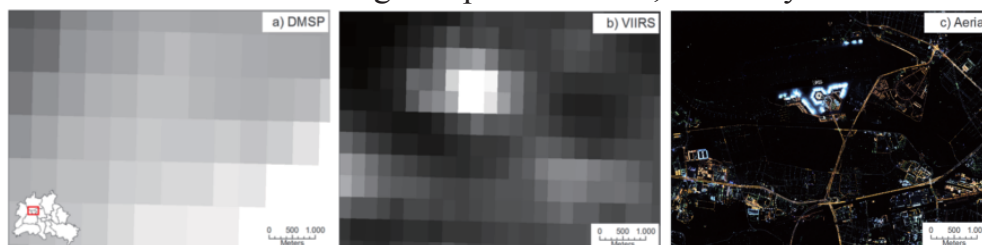


Remote Sensing: Kyba 2015

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)

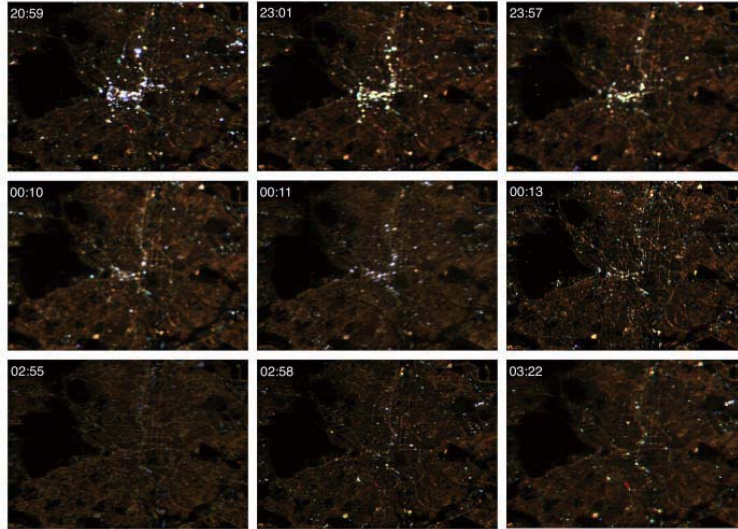
DNB-VIIRS
(~750m)

aerial
(~1m)

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Result highlights

- City light changes dynamically over the course of the evening

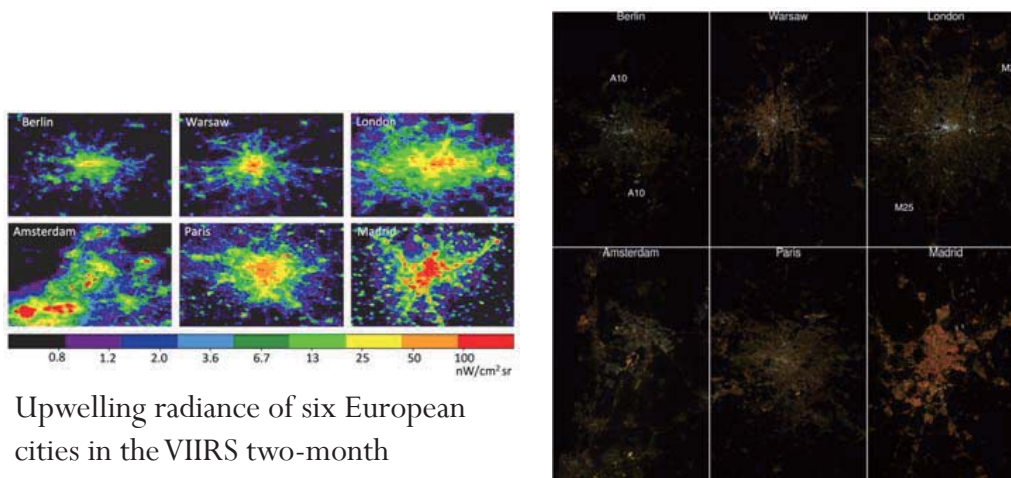


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ISS images of Madrid at different times of night (resolution $\sim 100\text{m}$)

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

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Measuring NSB

3. Dedicated devices

- DigiLum luminance meter, Mark Light Meter, Sky Quality Meter (SQM), etc
- **Advantages:**
 - Balance between accuracy (± 0.1 mag arcsec⁻²) and cost (~ USD 300 per unit)
 - Easy to use
 - High data sampling frequency (several seconds)
- **Disadvantages:**
 - Single band measurement
 - An average of the spatial variations of night sky

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Dedicated device: Pun et. al. (2014)

Pun C. S. J. et. al. 2014, Journal of Quantitative Spectroscopy & Radiative
Transfer, 139, 90

- 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/astronomy/astro_portal.html

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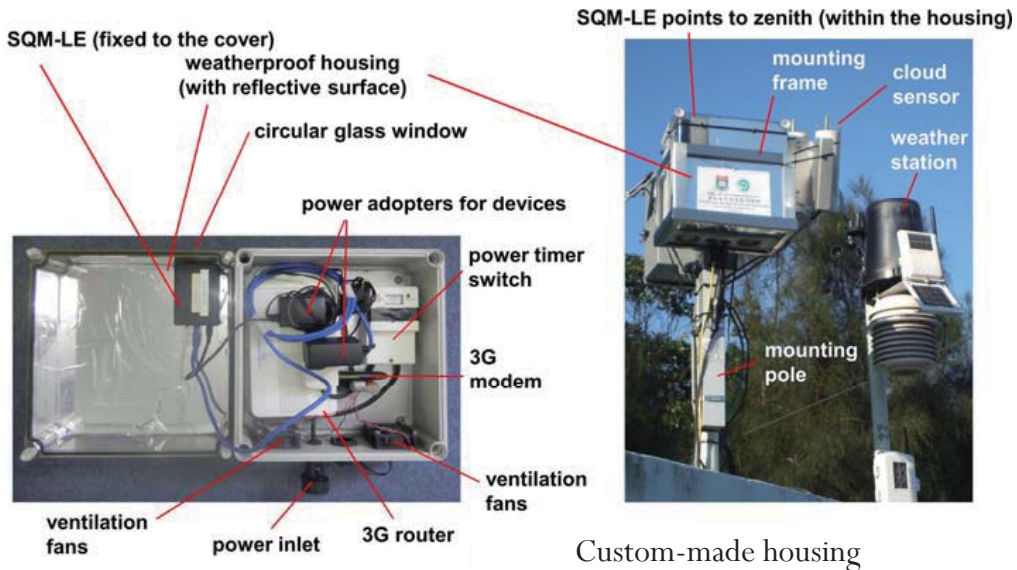
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Measuring NSB by SQM-LE



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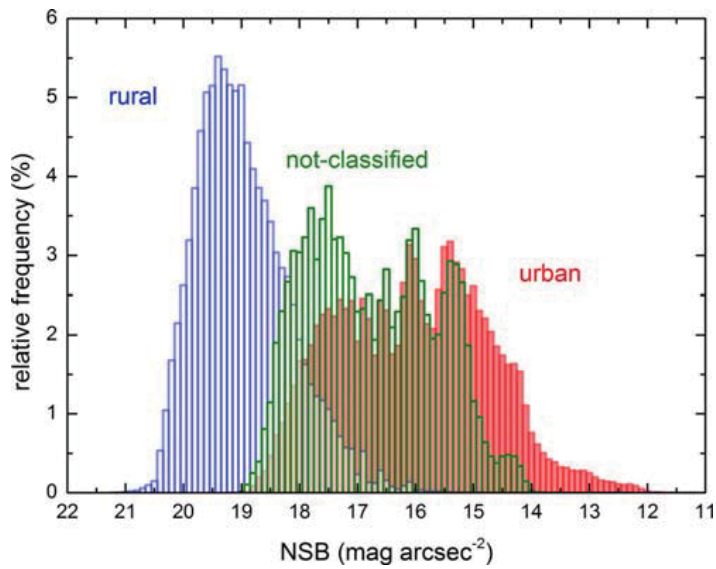


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Result highlights

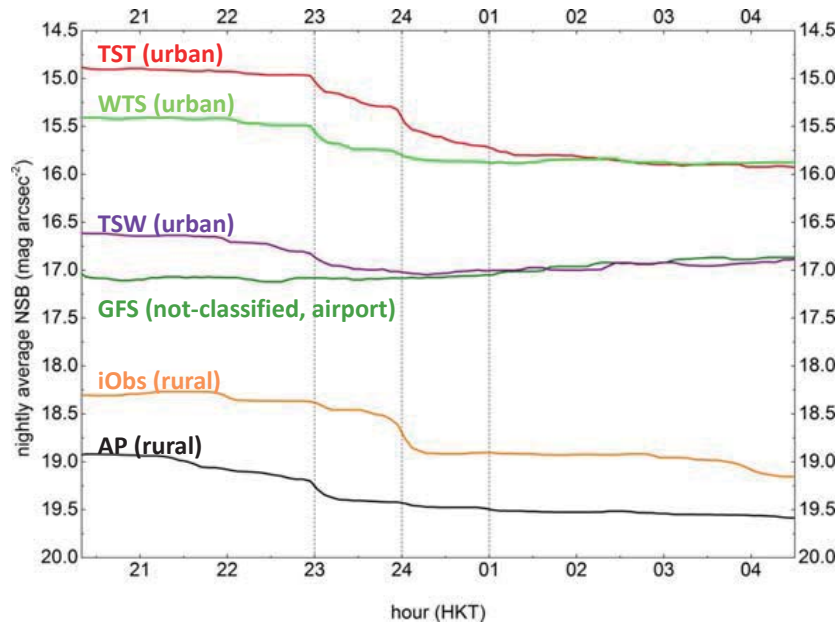
- Night sky brightness depends on location



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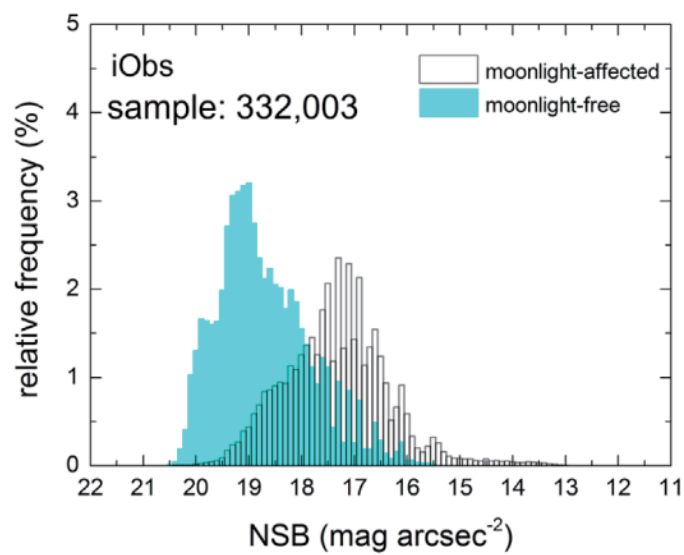
Result highlights

- Night sky brightness depends on time



Result highlights

- moonlight impacts on rural NSB observations



NSB database - data selection criteria

- NSN operation: May 2010 – March 2013
 - Total number of stations: 18
 - Data collection frequency: 1 to 5 minutes
- Basic principle: every single data point collected will be included in the database for analysis
- Exception: Sunlight
 - Data taken within 70 minutes after sunset or before sunrise were excluded
- Exception: “non-night-sky” events ($\sim 5\%$ of sunlight-free data)
 - Stargazing events (some are near stargazing or education hotspots)
 - On-site maintenance and servicing
 - Unphysical NSB readings e.g., <10 mag, >22 mag
 - *Astronomical events* (e.g., lunar eclipse)

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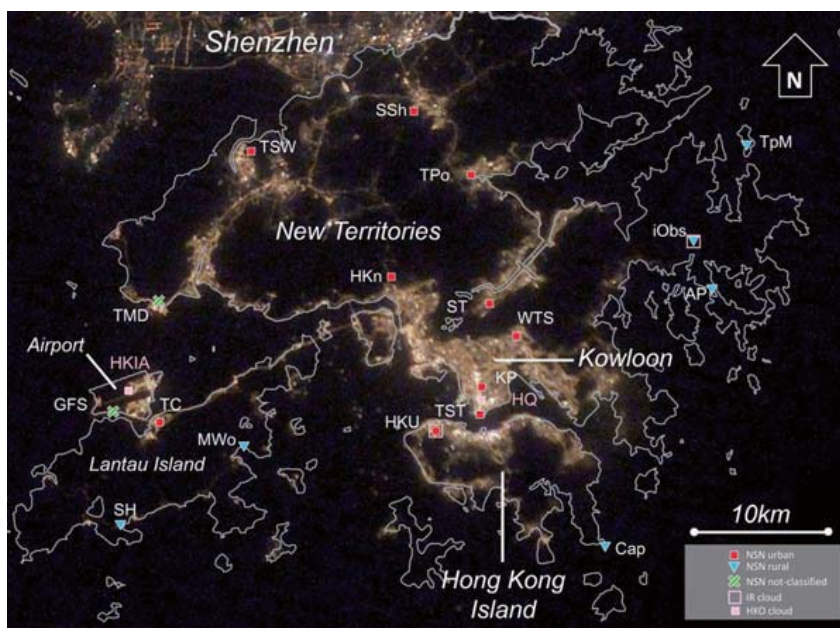
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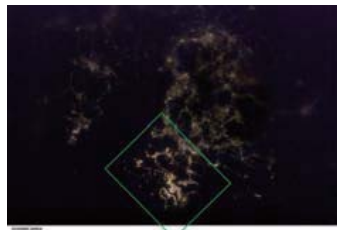
Cross-checking satellite with ground-based measurements SO (2014, PhD thesis)



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Credit: Science and Analysis Laboratory, NASA-Johnson Space Center, The Gateway to Astronaut Photography of Earth

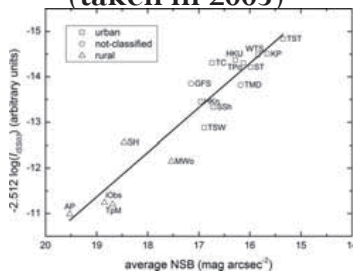
Methodology: comparison of SQM readings with the ISS night-time image



Raw photo at ~ 68 m resolution
(taken in 2003)



Georeferencing



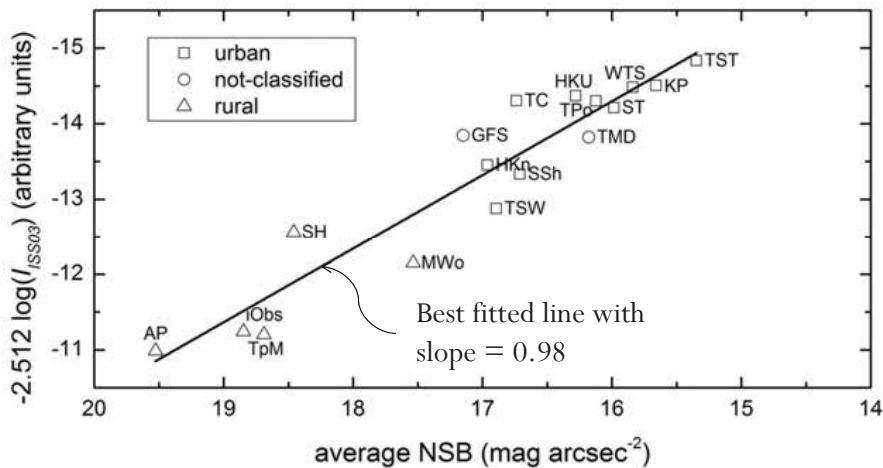
Compare to SQM readings
(taken in 2010-2013)



Dark frame subtraction

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Result highlights



- The correlation between remote sensing data (2003, y) and the ground-based measurements (2010-2013, x) was strong
- \rightarrow potentials of space-based study of light pollution

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Night Sky Brightness Measurements

	Application	Geographic coverage	Temporal coverage	Cost	Accuracy	Major pro	Major con
Traditional CCD photometry	Analyze night sky properties of a site in detail	👍	👍	👍	👍👍👍	High accuracy	High cost
Wide-field photometry	Analyze sources of light pollution	👍👍	👍👍	👍👍	👍👍	Directional information	Calibration challenge
Remote sensing	Analyze light pollution conditions across cities	👍👍👍👍	👍	👍👍👍	👍👍	Large geographic coverage	Calibration challenge
Citizen science	Analyze light pollution conditions across regions	👍👍👍	👍👍👍	👍👍👍👍	👍	Spread light pollution messages, cheap, large coverage	Low accuracy for visual-only contributions
Dedicated NSB devices	Analyze light pollution conditions within regions	👍👍	👍👍👍	👍👍👍	👍👍	Cheap and accurate	Single-band only, lack directional information
Night sky spectroscopy	Analyze sources of light pollution	👍	👍👍	👍👍	👍👍	Obtain spectral information	Calibration challenge

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Night Sky Brightness (NSB) Measurements

- An expanded approach of the Hong Kong Monitoring Network:
 - Comprehensive and accurate measurements of the night sky brightness in different locations
 - A unified approach in data-taking and data-selection
 - Capture the dependence of NSB on a large number of natural and artificial factors
 - **Light pollution as a local problem, with local data, and hopefully local solutions**

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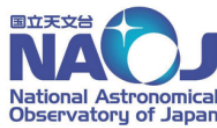


The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Co-organizers:
 - Office of Astronomy Outreach, International Astronomy Union (IAU)
 - National Astronomical Observatory of Japan
 - The University of Hong Kong
 - The Globe at Night project, National Optical Astronomical Observatory (NOAO)



INTERNATIONAL
YEAR OF LIGHT
2015



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The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- **Goal: Establish a global night sky brightness monitoring network**
- Endorsed by the IAU Executive Committee Working Group for the International Year of Light 2015 as a **major Cosmic Light program in support of the IYL**
- “Suggestions were to *“coordinate ... with others who are pursuing the educational aspect in other regions.”*”



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The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- First GaN-MN User Workshop on Jan 7-9, 2015 at National Astronomical Observatory Japan
- ~25 participants from 7 countries/regions



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Measuring NSB by SQM-LE



Credit: Unihedron

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

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The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- GaN-MN currently has:
 - 16 stations operating in 8 countries/regions in 3 continents
 - 3 stations in Korea
 - Over eleven million individual measurements had been collected by May 2016.

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Globe at Night - Sky Brightness Monitoring Network



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Red: current stations (16 as of Apr 2016)
Blue: potential stations (3 as of Apr 2016)



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GaN-MN in Korea



충북대학교 천문대
Chungbuk National University Observatory



충주고구려천문과학관
Muju Astronomical Observatory



대전시민천문대
Daejeon Astronomical Observatory



영양군 자연생태공원관리사업소
반딧불이담당 박제훈
Yeongyang Firefly Astronomical Observatory

The Globe 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 protective housing by the manufacturer
 - 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!

Thank you!

For more information on the GaN-MN,

- 1) Visit: <http://globeatnight-network.org/>
- 2) Email us at: globeatnight.network@gmail.com or
gan-mn@qq.com

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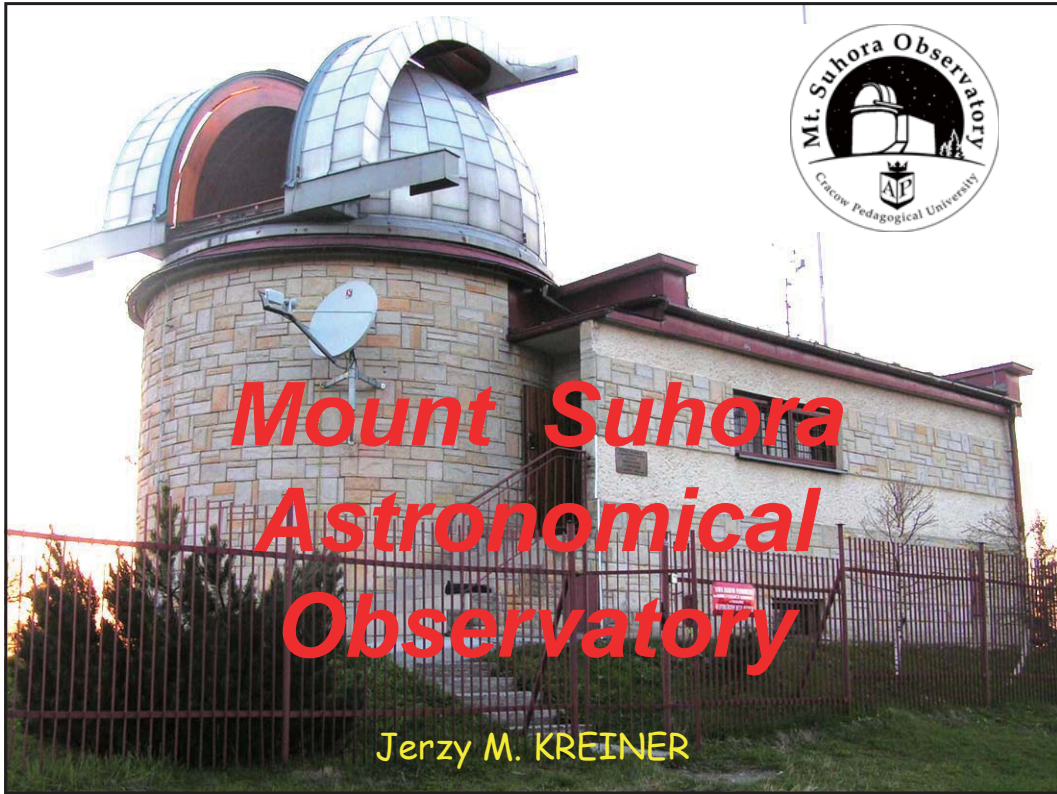


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Some information:



Polska
POLAND

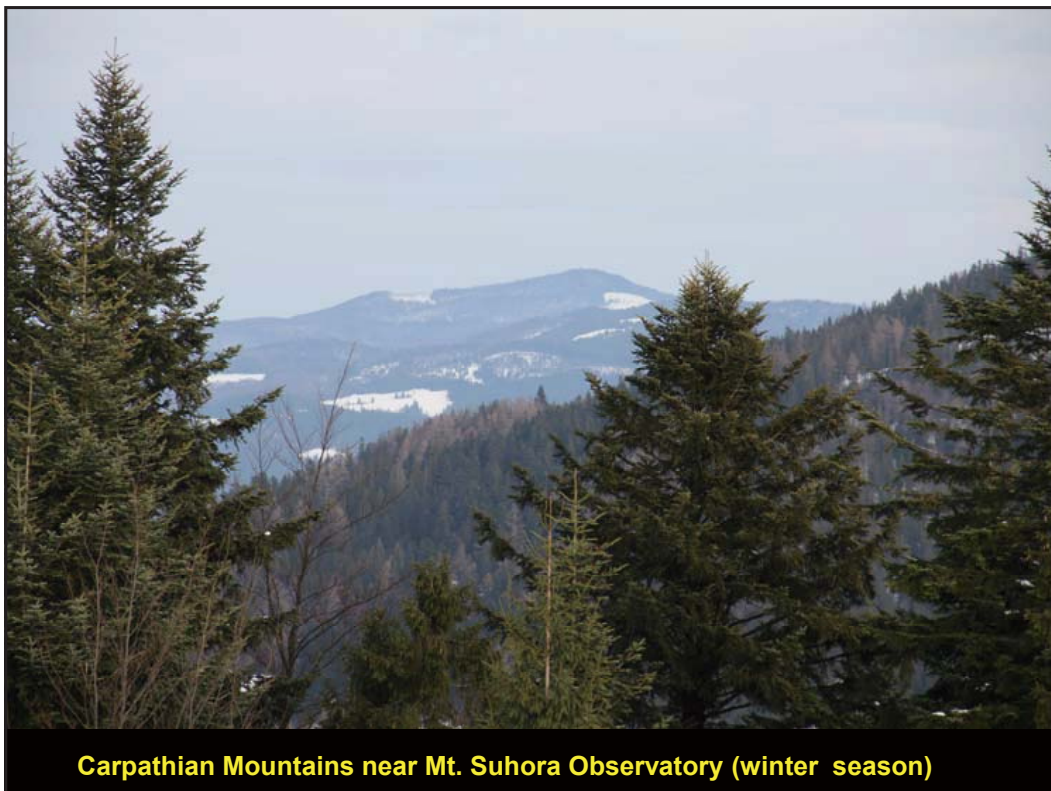


대한민국
KOREA

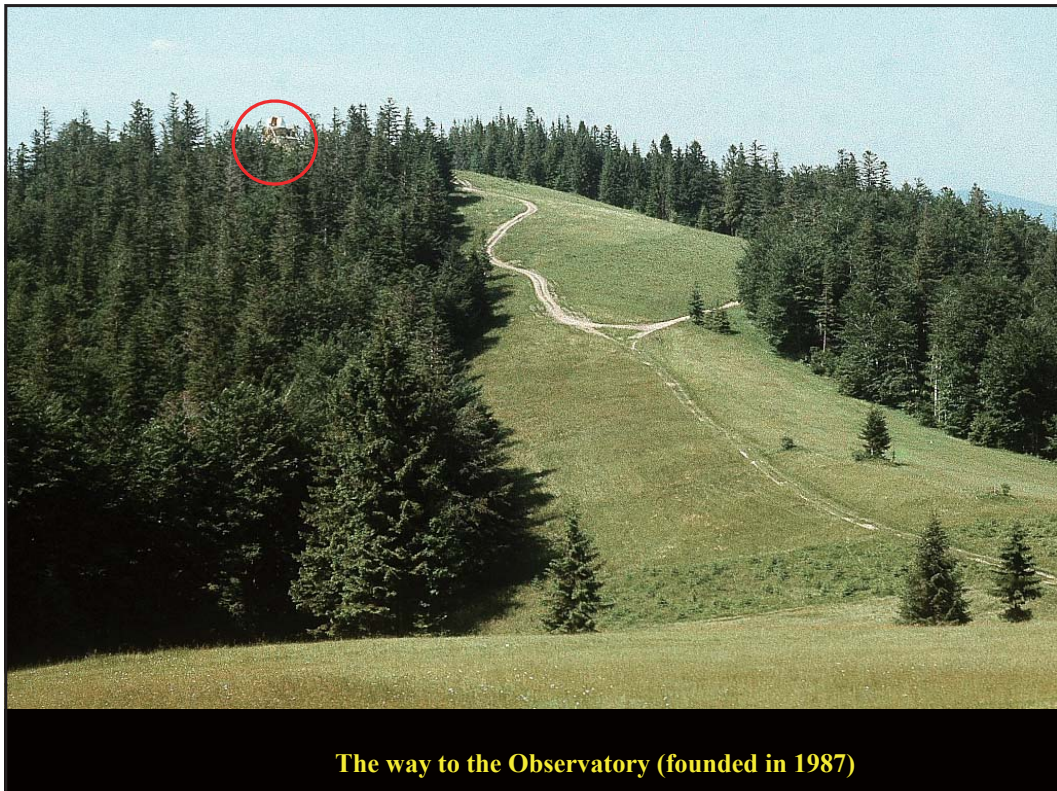
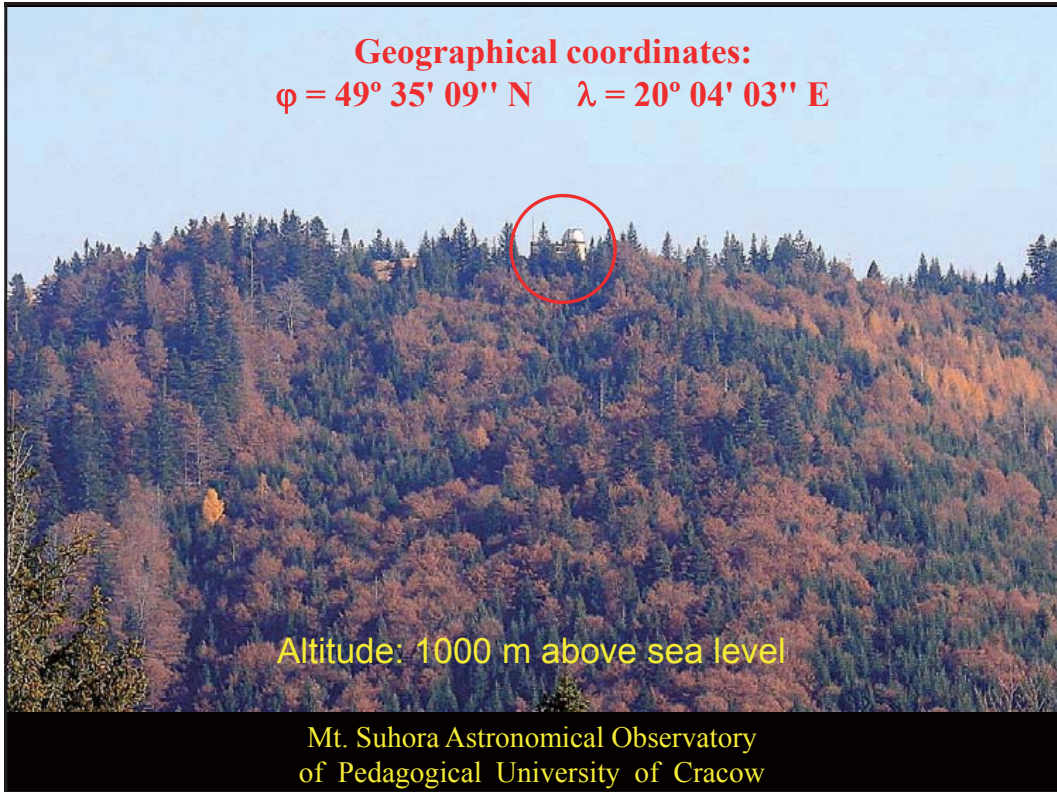
Population	38,4 mln	51,5 mln
Area	312 600 km ²	100 210 km ²
Capital	Warsaw (<i>Warszawa</i>) (1.2 mln)	Seoul (서울시) (10.1 mln)
Highest peak	Rysy (2499 m)	Halla-san (1950 m) (Jeju-do)

Search for good place for the observatory:

- very distant from cities
- very distant from industry centers
- as high as possible above sea level
- good transportation and communication

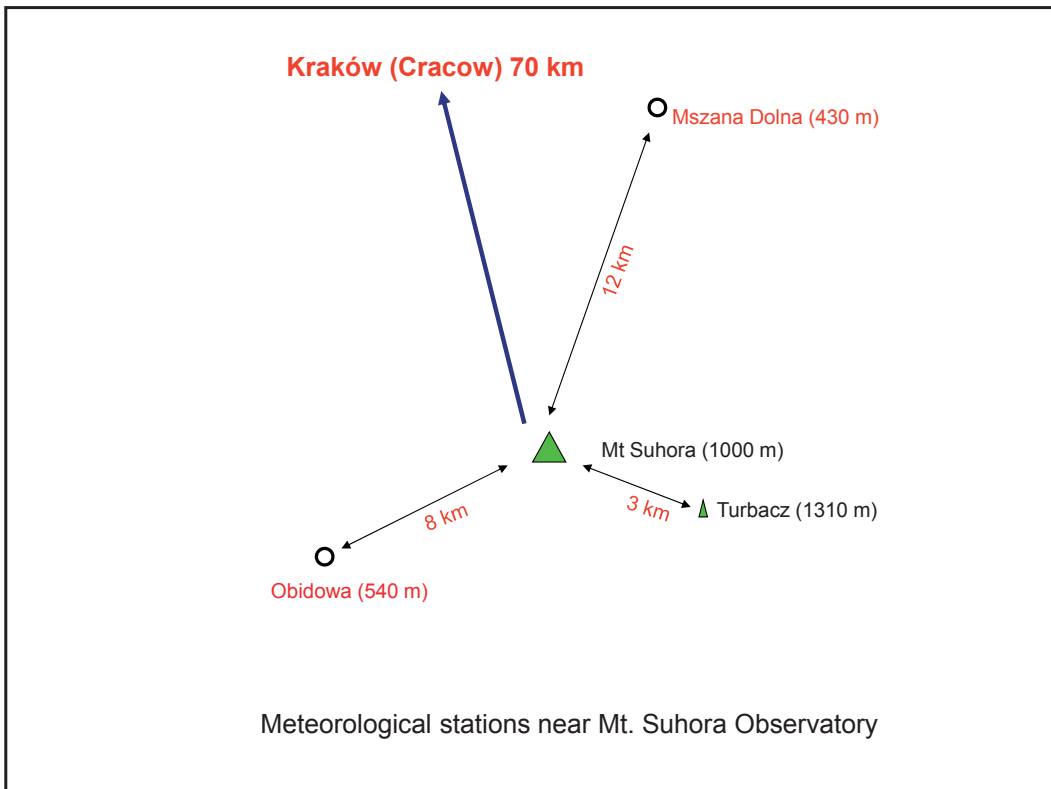


Carpathian Mountains near Mt. Suhora Observatory (winter season)

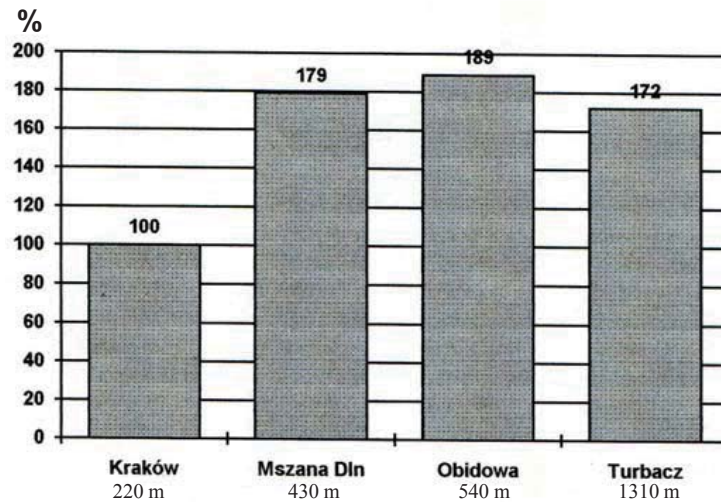




**Transportation
to the Observatory:
Chair-lift**



Mean number of observational hours for some places near Mt. Suhora (1000 m)
 (according to results of meteorological observations in the years 1960-1974)
 Kraków (Cracow) = 100%

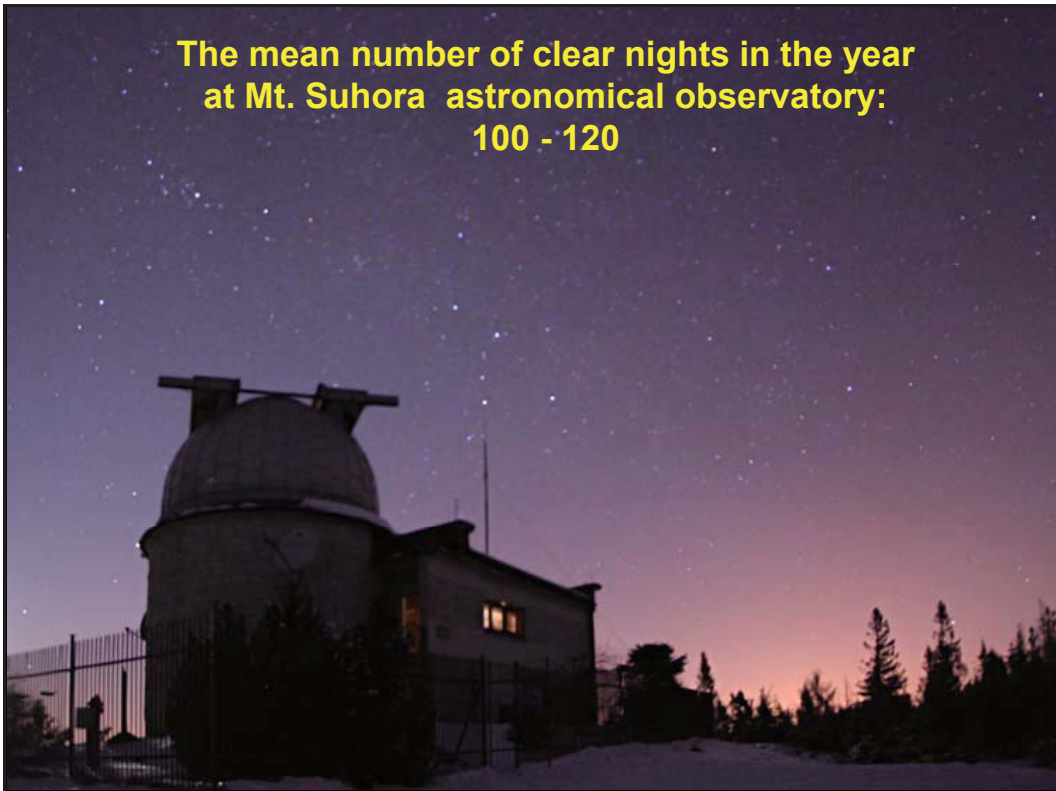


Some facts from the history of Mt. Suhora Observatory

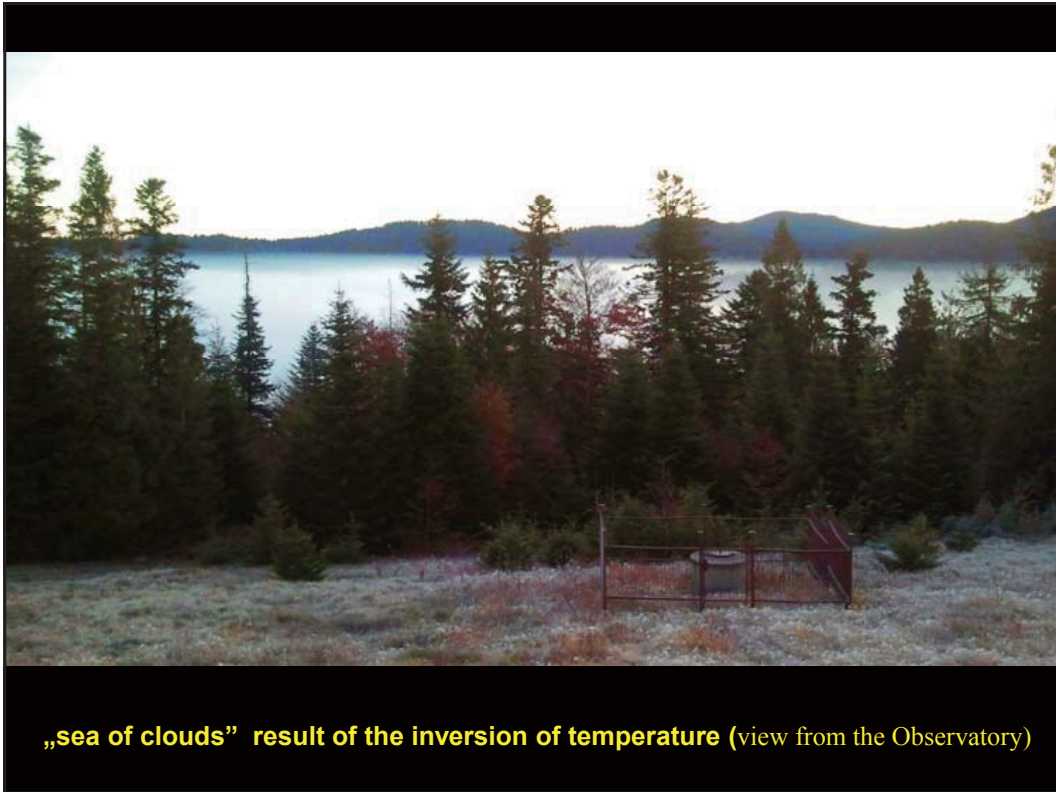
- | | |
|------------------|--|
| January 1984 | The localization of the Observatory was accepted |
| July 24, 1986 | The corner stone was laid |
| October 4, 1987 | The „first light” – observations of Jupiter |
| November 5, 1987 | The official opening of the Observatory |



The future site of the dome (May 1986)



The mean number of clear nights in the year
at Mt. Suhora astronomical observatory:
100 - 120

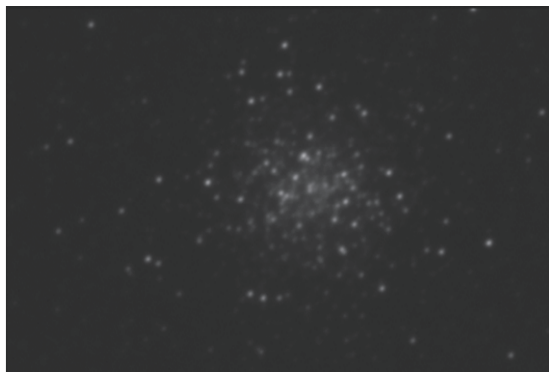
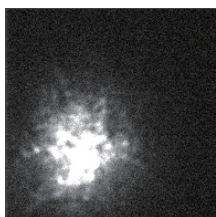


Seeing

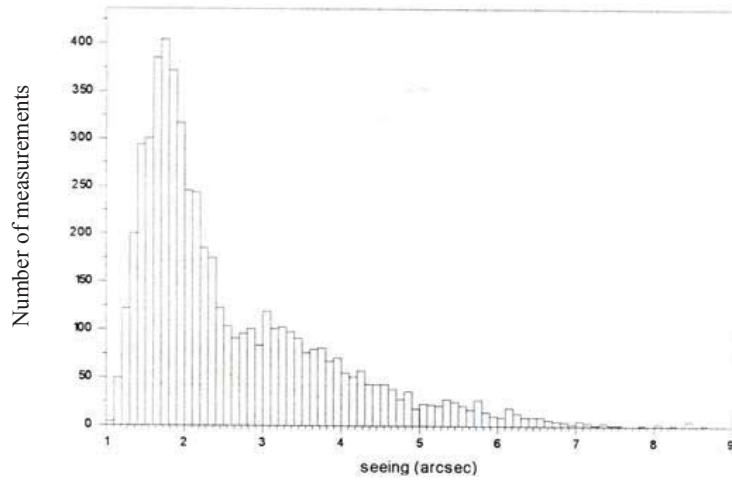
2"

Min 1,5"

Max 6"



The values of seeing at Mt. Suhora Observatory (September 1995 – April 1997)

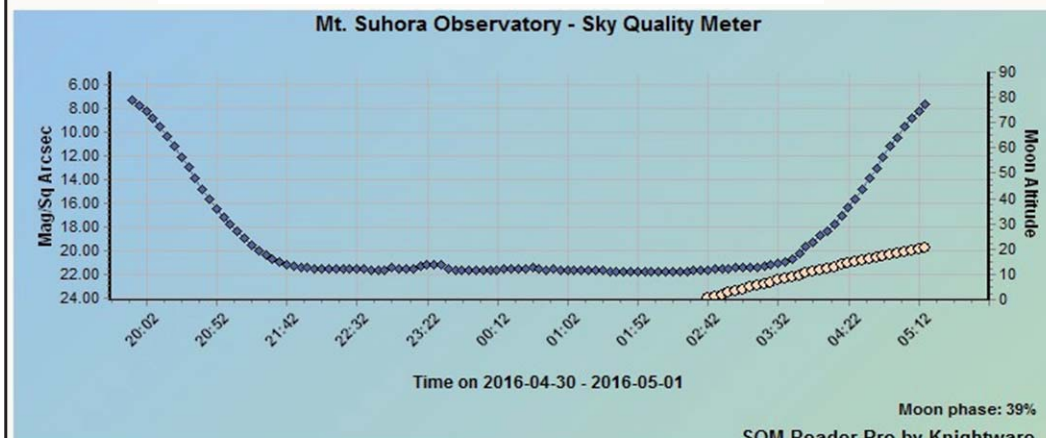


Typical: 1,8 arcsec
The best value: 1,06 arcsec

<i>Filter</i>	<i>Mean extinction coefficient</i>
<i>U</i>	<i>0.539</i>
<i>B</i>	<i>0.292</i>
<i>V</i>	<i>0.213</i>
<i>R</i>	<i>0.120</i>
<i>I</i>	<i>0.092</i>

A nighttime photograph of the Mt. Suhora Observatory. The main feature is a large, multi-lobed dome structure made of stone or brick, with several smaller domes on top. The interior of the domes is illuminated, creating a warm glow. The sky is dark and filled with stars. In the foreground, there are some dark silhouettes of trees and a satellite dish on a pole.

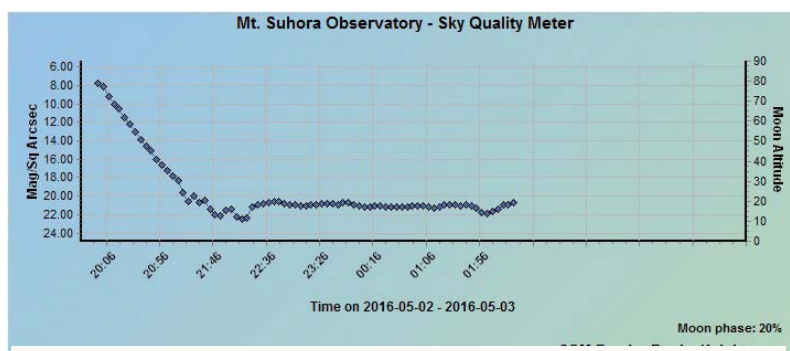
The brightness of the night sky at Mt. Suhora Observatory
April 30th / May 1st, 2016



Czujnik pomiarowy zainstalowano w ramach współpracy Katedry Astronomii Uniwersytetu Pedagogicznego z Pracownią Monitoringu Zanieczyszczenia Świetnego Politechniki Krakowskiej

Reading in Mag/Sq Arcsec	NELM (Theoretical)
7.45	-6.2
Time of Reading	Moon Altitude, Phase
2016-05-01 05:17:39	+20°, 39%

Jasność nocnego nieba



Czujnik pomiarowy zainstalowano w ramach współpracy Katedry Astronomii Uniwersytetu Pedagogicznego z Pracownią Monitoringu Zanieczyszczenia Świetnego Politechniki Krakowskiej

20.70	5.9
Time of Reading	Moon Altitude, Phase
2016-05-03 02:26:20	-12°, 20%

More information:



Dr Tomasz Sciezor

Tadeusz Kościuszko University of Technology

sciezor@vistula.wis.pk.edu.pl



The main telescope
of Mt. Suhora Observatory
Year of production: 1985

**Cassegrain-
Spiegelteleskop
600/7500**





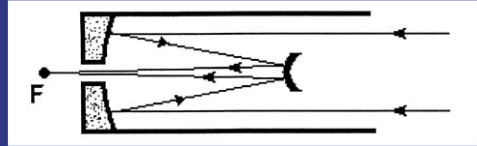
September 1987



September 1987



The main telescope: Cassegrain system



The diameter of the main mirror: 0.6 m
The focal length of the main mirror: 2.4 m
*The equivalent focal length
Cassegrain system: 7.5 m*
*The diameter
of the secondary mirror 0.18 m*
The weight of the telescope: 2760 kg



EVOLUTION OF THE PHOTOMETRIC EQUIPMENT

May 10, 1988
 First observations
 with the one-channel photometer
 equipped with uncooled
 EMI 9865B photomultiplier
 by Staszek Zola
 (CK Bootis)

COMMISSION 27 OF THE I. A. U.
 INFORMATION BULLETIN ON VARIABLE STARS
 Number 3251

Konkoly Observatory
 Budapest
 17 October 1988
 HU ISSN 0374 - 0676

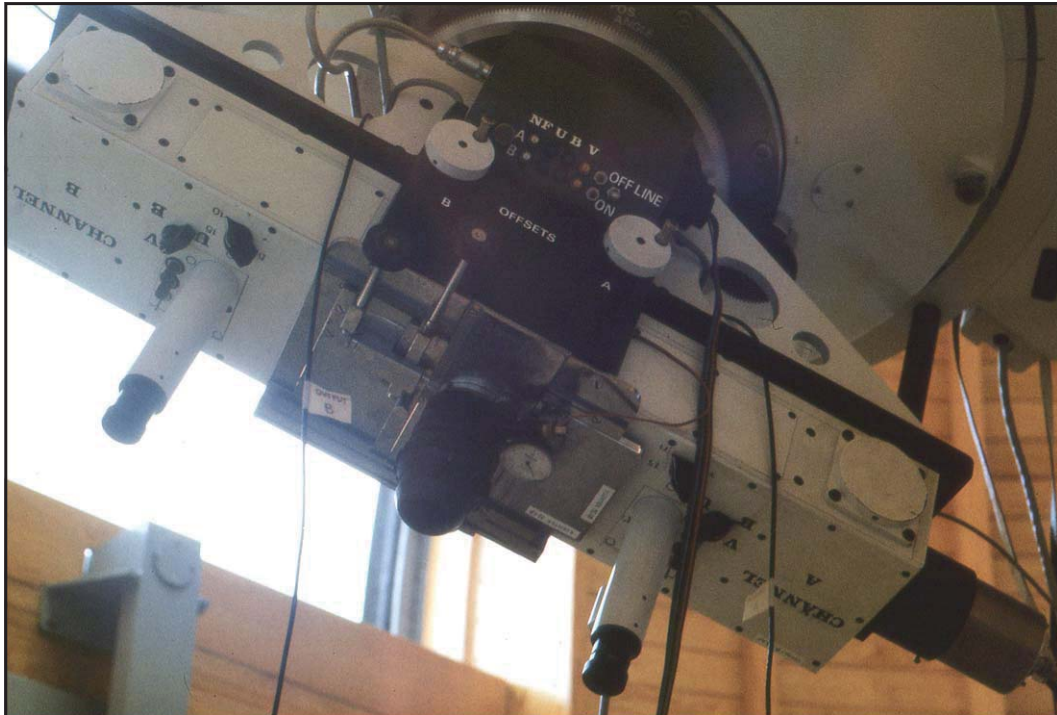
NEW ELEMENTS OF CK Boo

The star CK Boo (HD 128141, BD +9d2916) is a W UMa-type eclipsing binary discovered by Bond (1975). Its light curve varies from night to night. Aslan and Dzeman (1986) suggested these long-term changes to be due to a starspot cycle with a period of about 7 years.

New photoelectric observations were obtained during May 1988 at Mt. Suhora Observatory (1000 m above sea level, $\phi = +49^{\circ}35'$, $\lambda = -1^{\circ}20'22''$) of the Pedagogical University (Cracow) using the 60 cm Cassegrain telescope equipped with a one-channel photometer. An uncooled EMI 9865B photomultiplier as well as blue and yellow filters close to UV Johnson-Morgan system were used. The data logging was controlled automatically by a Commodore-64 microcomputer.

The observations allowed us to determine the following times of minima by parabolic fitting:

JDhel	Filter	Minimum type
2447290.4153 +/- 0.0007	V	II
47290.4146 +/- 0.0007	B	II
47291.4796 +/- 0.0003	V	II
47292.3699 +/- 0.0005	V	I
47298.4072 +/- 0.0002	V	I

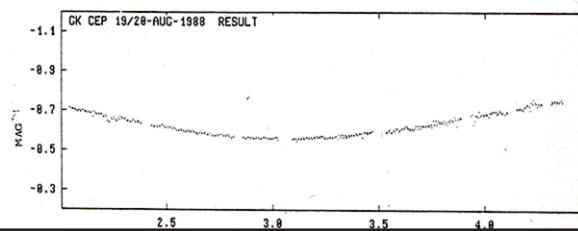
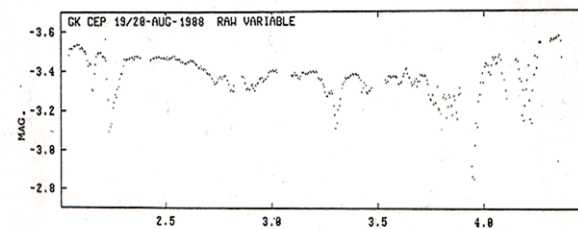
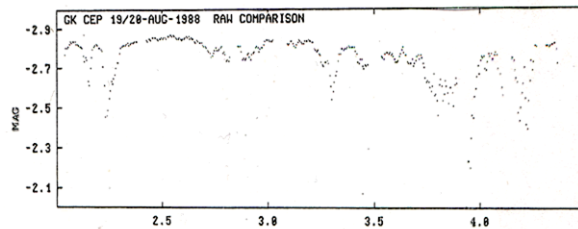


First dual-channel photometer used at the Observatory in the years 1988 - 1990

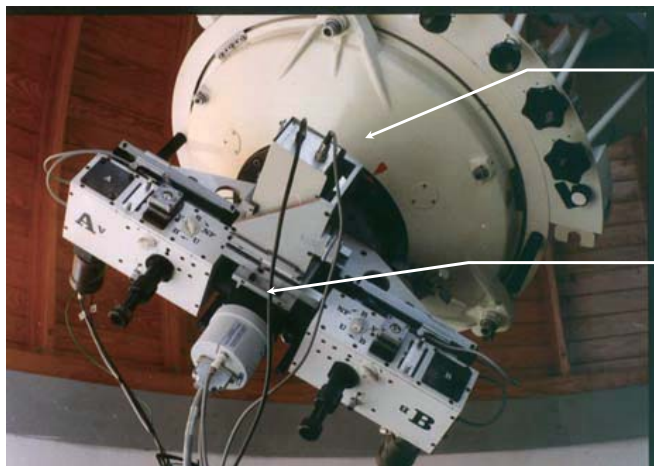
Observations of GK Cep
(dual-channel photometer)

Bad weather!

August 19/20, 1988



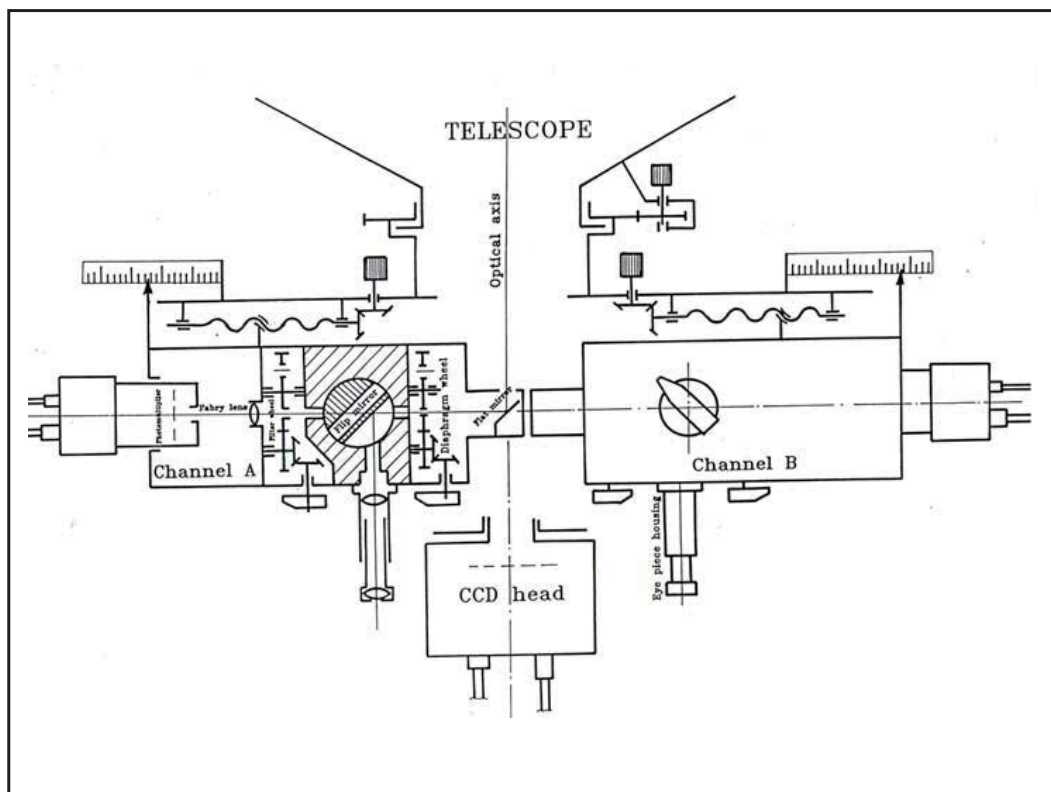
Dual-channel photometer + CCD camera **Photometrics STAR-1**
 used at the Observatory since 1990
 (constructed at the Pedagogical University of Cracow)



Nightvision camera

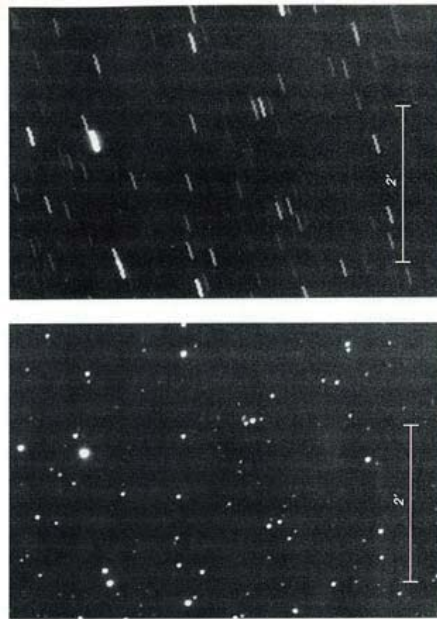
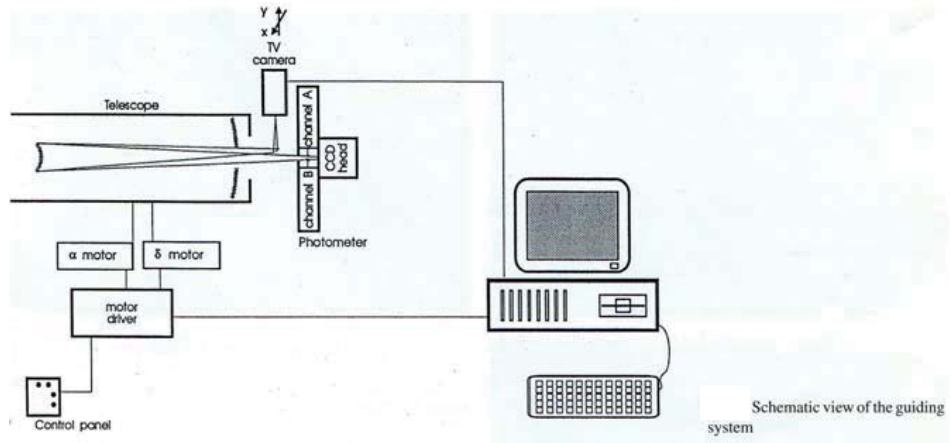
CCD Camera
 Photometrics Star 1

References:
 Proceedings of the IAU Coll No 136.
 Dublin Ireland, 1992
 Ed. I. Elliott & C.J. Butler



Multi-task guiding system of the Mt. Suhora Observatory

J. Krzesiński and K. Wójcik

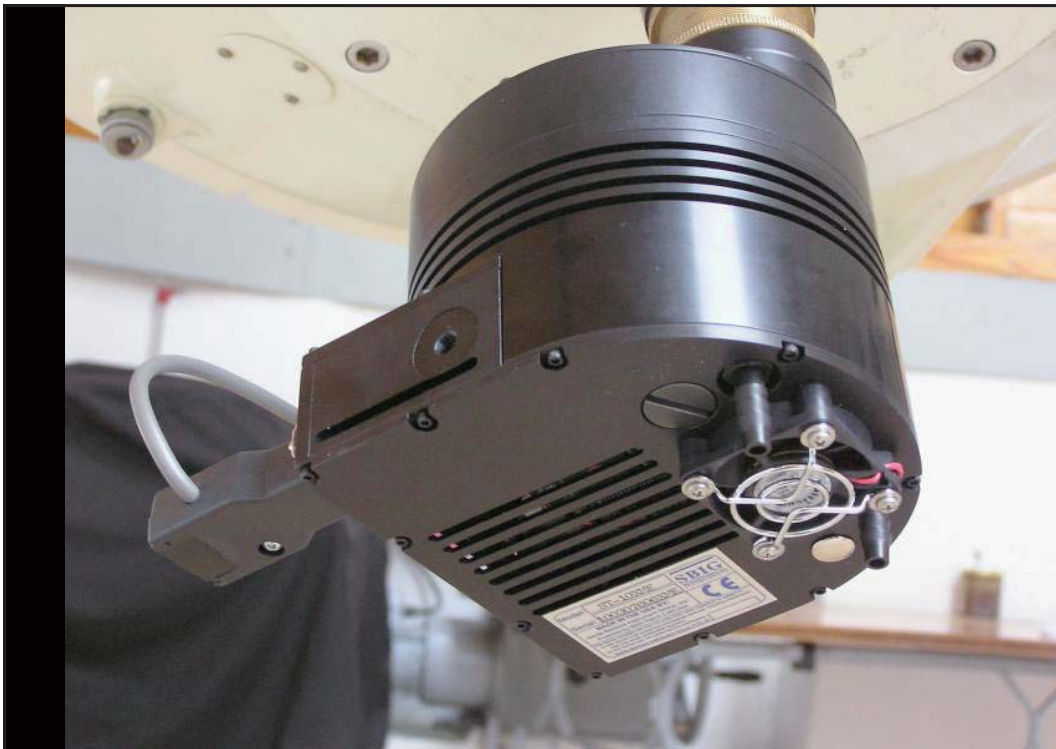


Fifteen minutes exposures of the same region in the sky: with no guiding (*upper*) and with working autoguider (*lower*)

J. Krzesiński, K. Wójcik,
Astron. & Astrophys. 280, 338 (1993)



Three-channel photometer made by Astronomical Observatory in Vilnius (Lithuania) used at the 60 cm telescope of Mt. Suhora Observatory since 2005

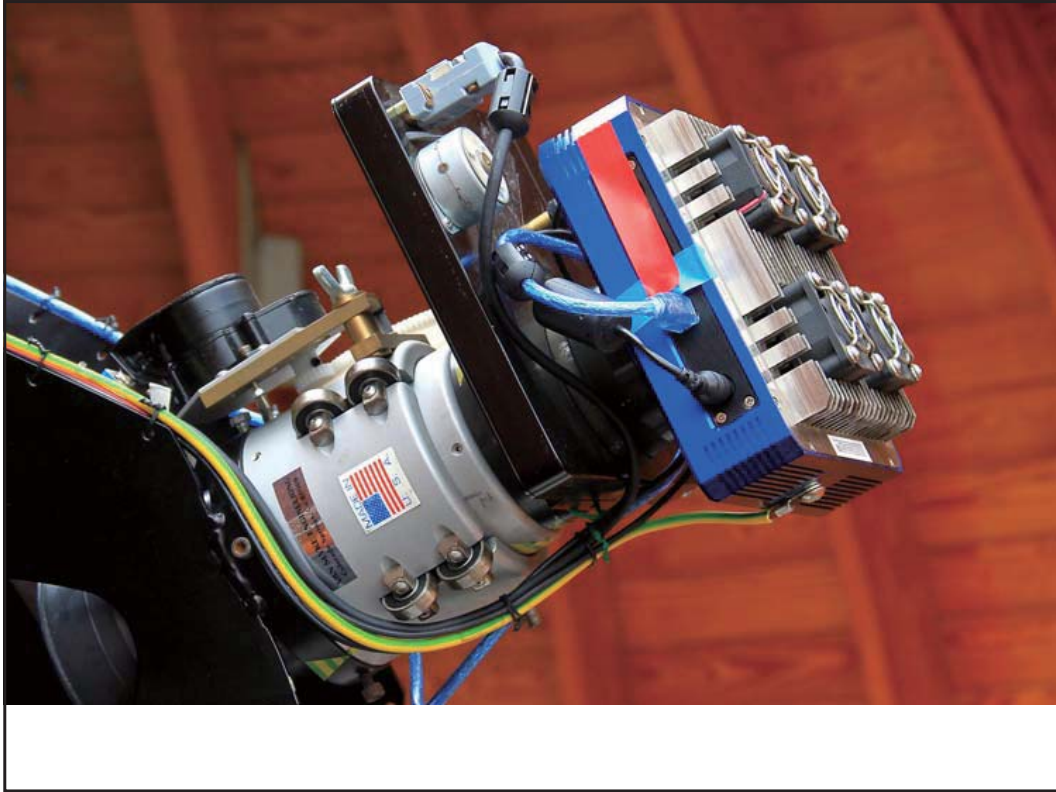


CCD camera SBIG ST10XME 2184 x 1472 pixels [14,9 x 10 mm]



New system of photometric observations: The CCD camera was put in the main focus of the telescope
Advantages: 1) larger field of view 2) less loss of light





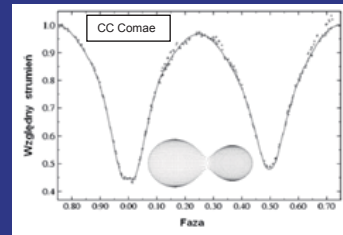
Some results of observations

Menu

Eclipsing binaries

W Ursae Majoris – type

- light curves
- modeling
- times of minima
- period changes



A&A 412, 465–471 (2003)
 DOI: 10.1051/0004-6361:20031456
 © ESO 2003

**Astronomy
 &
 Astrophysics**

Physical parameters of components in close binary systems. I

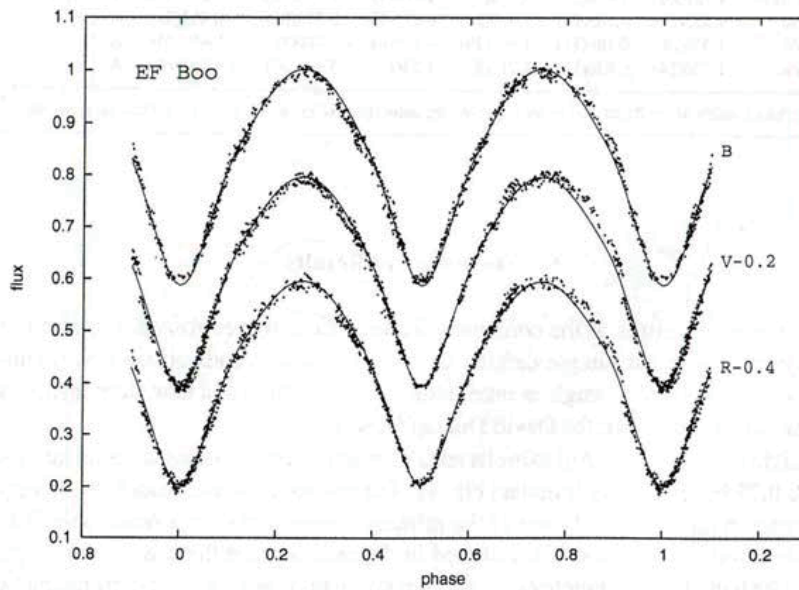
J. M. Kreiner¹, S. M. Rucinski², S. Zola³, P. Niarchos⁴, W. Ogloza¹, G. Stachowski^{1,5}, A. Baran^{1,6}, K. Gazeas⁴,
 M. Drozd¹, B. Zakrzewski¹, B. Pokrzywka¹, D. Kjurkchieva⁷, and D. Marchev⁷

Astrophys Space Sci (2006) 304:71–73
 DOI 10.1007/s10509-006-9077-0

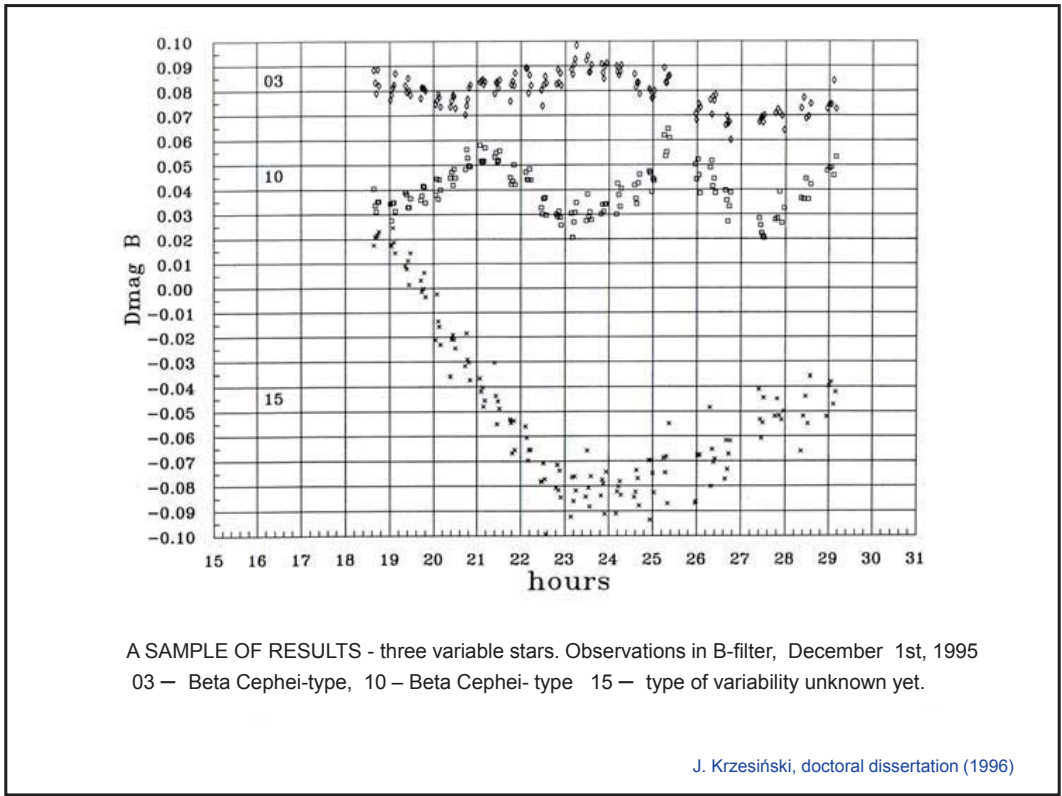
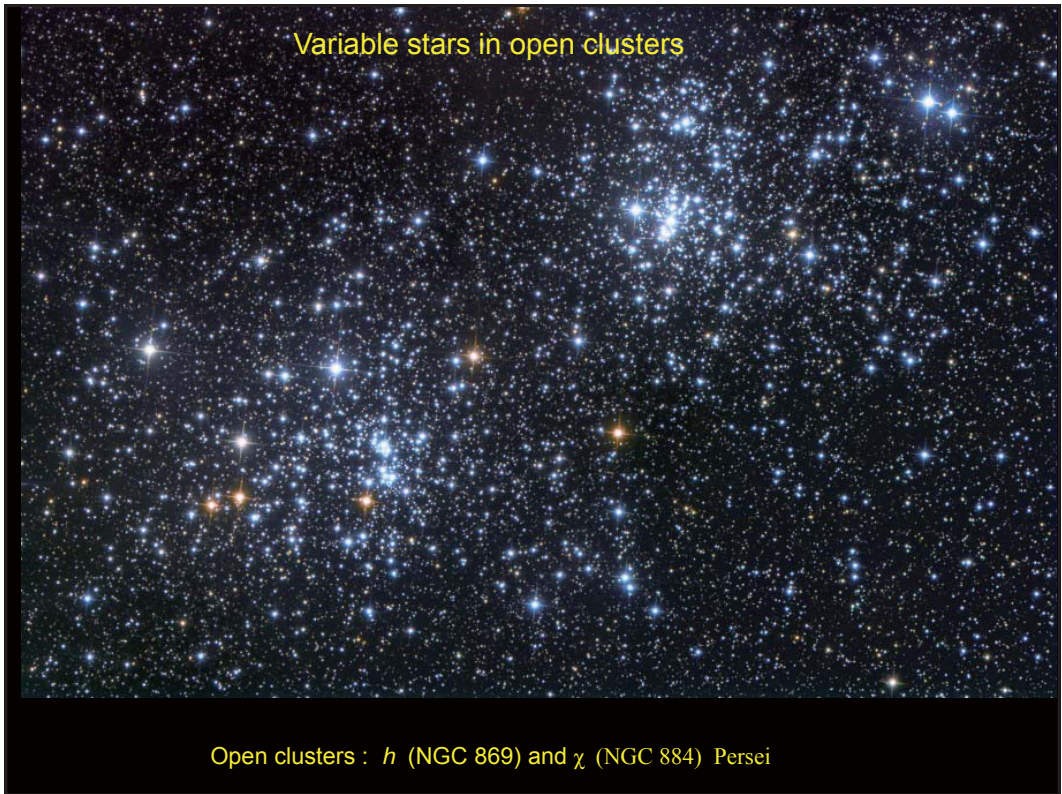
ORIGINAL ARTICLE

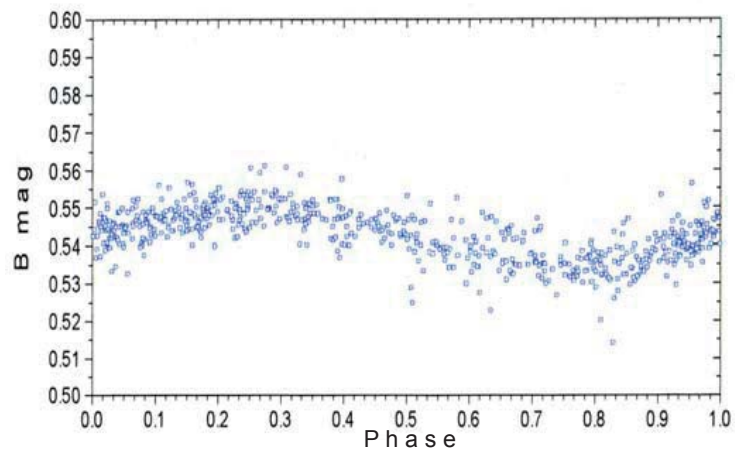
The W UMA-type Stars Program: First Results, Current Status and Perspectives

J. M. Kreiner · S. Zola · W. Ogloza · B. Pokrzywka ·
 M. Drozd · G. Stachowski · B. Zakrzewski ·
 P. G. Niarchos · K. Gazeas · S. M. Rucinski · M. Siwak ·
 D. Koziel · D. Kjurkchieva · D. Marchev



Comparison between theoretical and observed light curves of EF Boo (*BVR* filters). Individual observations are shown with dots and theoretical curves with solid lines.





The star: Oo 2299 (χ Persei)

Typ: β Cephei

V[mag] = 9.11; B-V = -0.27

P[d] = 0.31792 (± 0.00002)

Ampl. [mag] = 0.0073 mag ± 0.0003

J. Krzesiński, doctoral dissertation (1996)

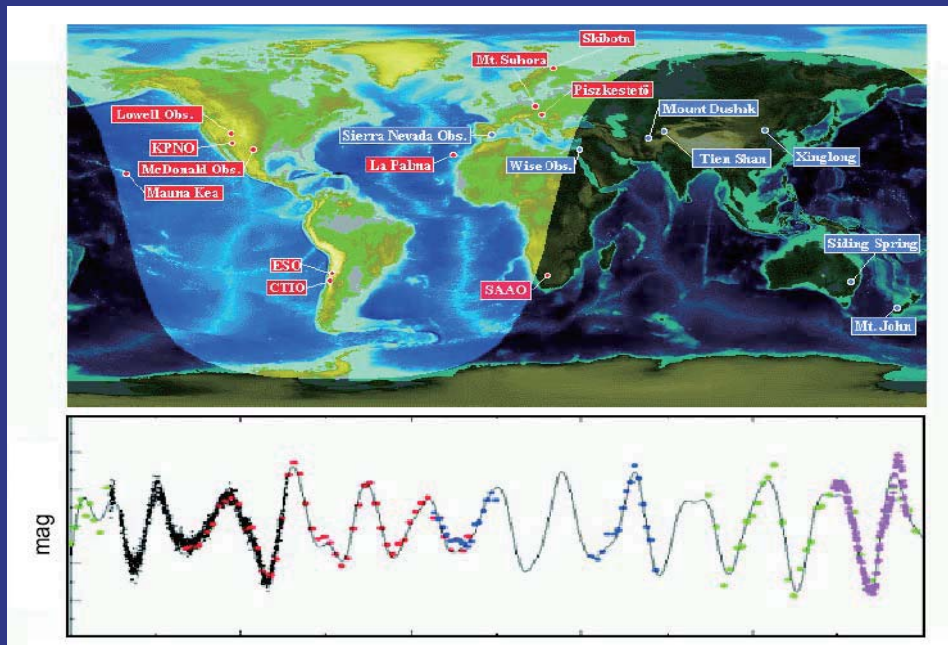


[THE WHOLE EARTH TELESCOPE] WET

1991: Mt. Suhora Observatory was included
in the group of observatories
(coordinated by Mc Donald Observatory, Texas, USA)

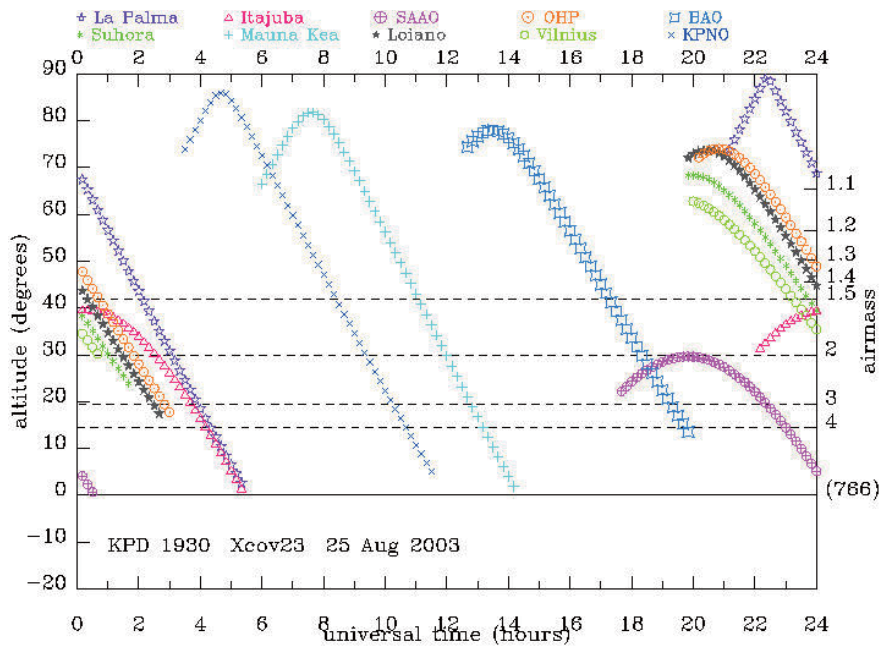


The main goal of the WET: to observe a given star for 24 hours



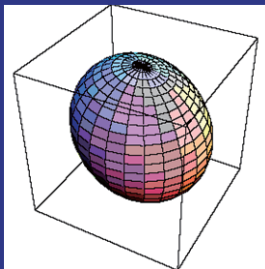
Mc Donald Observatory, Texas
Kitt Peak National Observatory, Arizona
Mauna Kea Observatories, Hawaii
CFHT (Canada-France-Hawaii Telescope), Hawaii
Mt. John Observatory, New Zeland
Mt. Stromio & Siding Spring Observatories, Australia
Beijing Astronomical Observatory, China
Vainu Bappu Observatory, India
Moletai Astronomical Observatory, Lithuania
Wise Observatory, Israel
South African Astronomical Observatory, South Africa
Mt. Suhora Observatory, Poland
Osseatorio di Bologna, Loiano Telescopes, Italy
Calar Alto Observatory, Spain
Observatoire du Pic du Midi, France
Observatoire de Haute-Provence, France
Observatorio del Teide, Tenerife, Spain
El Rogue de Los Muchachos Obseatory, La Palma, Spain
Nordic Optical Telescope, La Palma, Canary Islands
Observatorio do Pico dos Dias, Brazil
Cerro Tololo Interamerican Observatory, Chile
European Southern Observatory, Chile
SARA, Arizona
Mt. Cuba Astronomical Observatory, USA

An example of WET observations: Xcov23

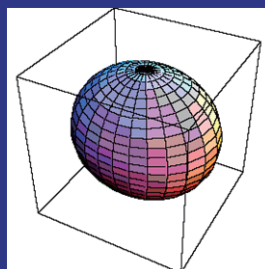


Most targets: pulsating stars

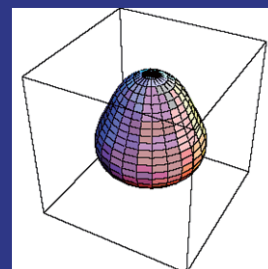
$\lambda = 2, m=1$



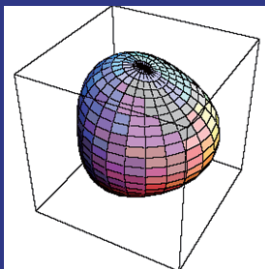
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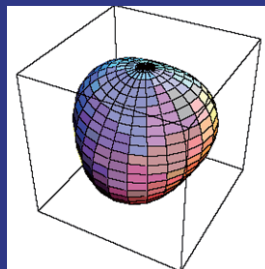
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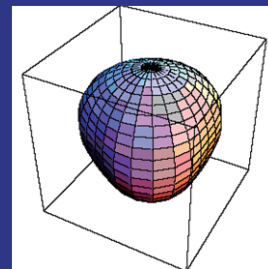
$\lambda = 3, m=1$

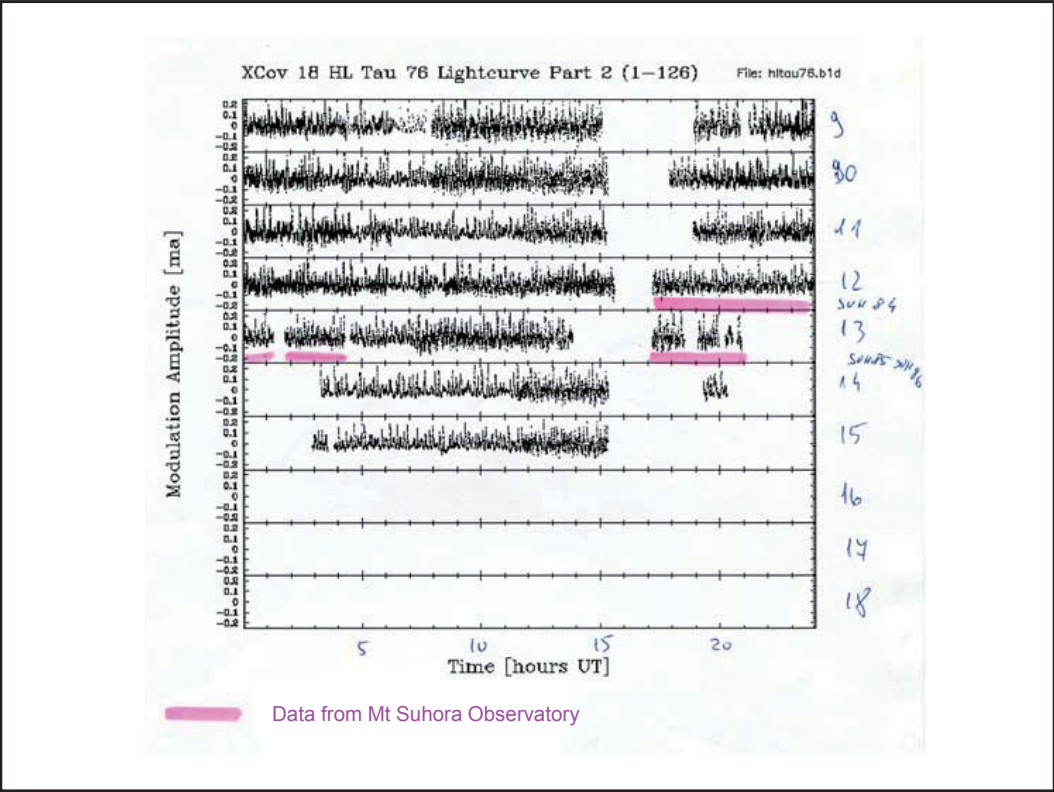
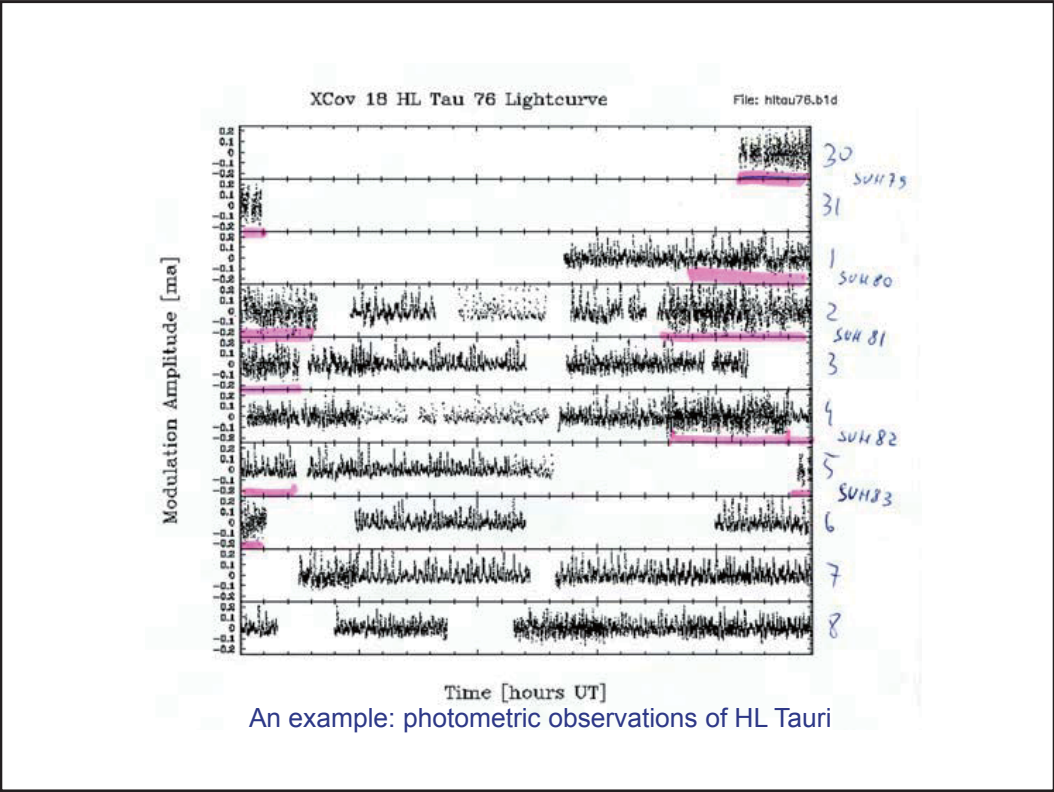


$\lambda = 3, m=2$



$\lambda = 3, m=3$

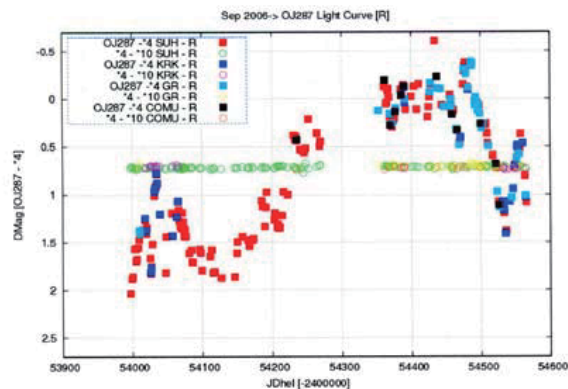




A massive binary black-hole system in OJ 287 and a test of general relativity

M. J. Valtonen¹, H. J. Lehto¹, K. Nilsson¹, J. Heidt², L. O. Takalo¹, A. Sillanpää¹, C. Villforth¹, M. Kidger³, G. Poyner⁴, T. Pursimo⁵, S. Zola^{6,7}, J.-H. Wu⁸, X. Zhou⁸, K. Sadakane⁹, M. Drozd², D. Koziel⁶, D. Marchev¹⁰, W. Ogloza⁷, C. Porowski⁶, M. Siwak⁶, G. Stachowski⁶, M. Winiarski⁶, V.-P. Hentunen¹¹, M. Nissinen¹¹, A. Liakos¹² & S. Dogru¹³

Krzywa zmian blasku kwazara OJ287 zaobserwowana w Polsce, Grecji i Turcji.
 Obserwacje wykonywane w Grecji i Turcji były przez nas koordynowane i redukowane
 (stan na 9-04-2008)



Nature 449, 189-191 (13 September 2007) |
 doi:10.1038/nature06143; Received 6 April 2007; Accepted 26 July 2007

A giant planet orbiting the 'extreme horizontal branch' star V 391 Pegasi

R. Silvotti¹, S. Schuh², R. Janulis³, J.-E. Solheim⁴, S. Bernabei⁵, R. Østensen⁶, T. D. Oswalt⁷, I. Bruni⁸, R. Gualandri⁹, A. Bonanno⁶, G. Vauclair¹⁰, M. Reed¹⁰, C.-W. Chen¹¹, E. Leibowitz¹², M. Paparo¹³, A. Baran¹⁴, S. Charpinet⁹, N. Dolez⁹, S. Kawaler¹⁵, D. Kurtz¹⁶, P. Moskalik¹⁷, R. Riddle¹⁸ & S. Zola^{14,19}

1. INAF-Osservatorio Astronomico di Capodimonte, via Moiariello 16, 80131 Napoli, Italy
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12. Wise Observatory, Tel Aviv University, Tel Aviv 69978, Israel
13. Konkoly Observatory, P O Box 67, H-1525 Budapest XII, Hungary
14. Cracow Pedagogical University, ul. Podchorążych 2, 30-084 Cracow, Poland
15. ...
16. ...
17. ...
18. ...
19. ...



more information:
www.as.up.krakow.pl



Thank you for your attention!



CONTENTS

- I 체험 프로그램의 필요성
 - II 체험 프로그램 기획
 - III 체험 프로그램 개발
 - IV Globe at Night
 - 3-1 Globe at Night 보고 자료
 - 3-2 Globe at Night 활동 방법
 - 3-3 Dark Skies Rangers의 활용
 - V 활동 계획
-

The Global at Night - Sky Brightness Monitoring Network in Korea



| 체험 프로그램의 필요성



Dark Skies Awareness

What is Light Pollution?



II 체험 프로그램 기획

▶ **Globe at Night(www.globeatnight.org ,USA)**

: Globe at Night 캠페인 번역

▶ **체험 프로그램 개발**

: Globe at Night의 Dark Skies Rangers를 활용한 빛공해
체험 프로그램 개발



III 체험 프로그램 개발

강의 진행 과정	강의 내용	강의 시간
Dark skies Awareness	위성 사진 및 상황 별 관측 결과를 활용하여 밤하늘에 대한 인식 고찰	10분
빛공해	'빛공해'의 이론 설명과 빛공해 방지 대책의 소개	10분
Globe at Night	활동 방법 소개	5분
별자리	스카이프로그램을 활용하여 별자리 찾는 법 교육	10분
실습 진행	활동지를 배부하여 별자리 찾기 및 실제 Globe at Night 활동 진행	30분
결과 보고	실습 결과를 보고하고 다른 보고 자료와의 비교 및 분석을 통해 Dark Sky와 빛공해를 경험적으로 인지	15분



IV Globe at Night 3-I Globe at Night 보고 자료

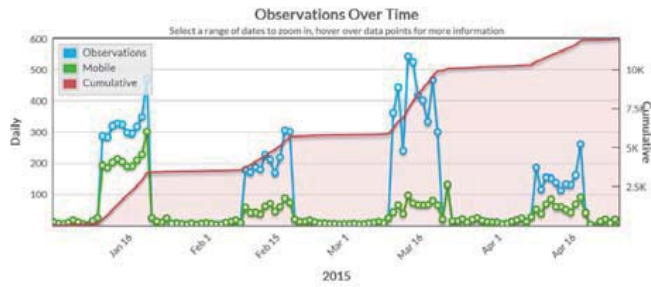
2015: Globe at Night Real-time Interactive Infographic

So far in 2015, Globe at Night has received

12,040 Observations

from **77** Countries

& **47** US states



IV Globe at Night 3-I Globe at Night 보고 자료

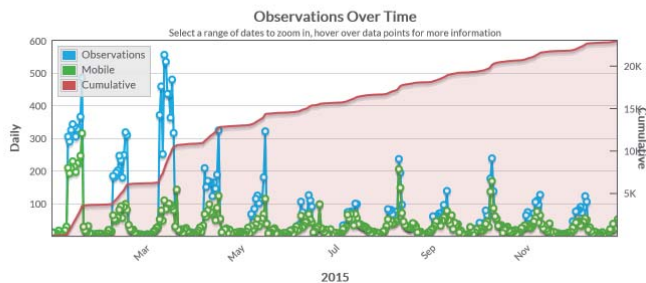
2015: Globe at Night Real-time Interactive Infographic

In 2015, Globe at Night received

23,052 Observations

from **104** Countries

& **50** US states



IV Globe at Night

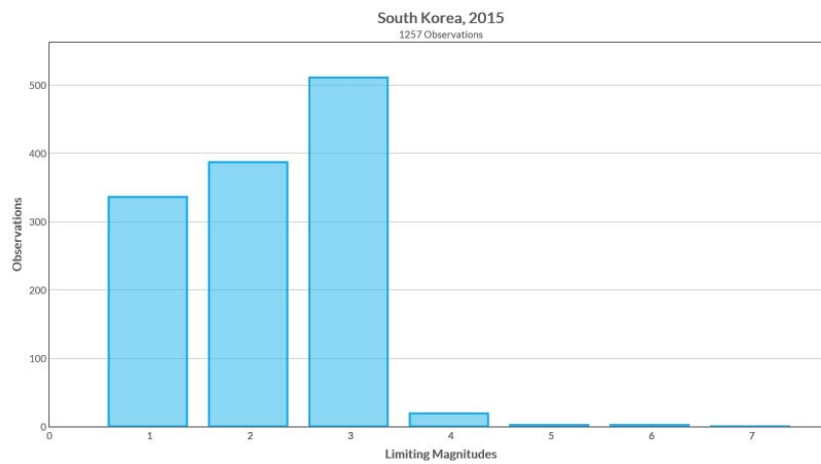
3-1 Globe at Night 보고 자료



IV Globe at Night

3-1 Globe at Night 보고 자료

Distribution of Observations by Area



IV Globe at Night 3-2 Globe at Night 활동 방법

Northern Constellations

2016



Orion
January 1-10, February 1-10, March 1-10, 2016



Leo
March 30-April 8, April 29-May 8, 2016



Bootes
May 29-June 7, 2016



Hercules
June 27-July 6, 2016



Cygnus
July 28-August 6, 2016, August 25-September 2, 2016,
September 22-October 1, 2016



Pegasus
October 21-31, 2016



Perseus
November 20-30, December 20-30, 2016

Southern Constellations

2016



Orion
January 1-10, February 1-10, 2016



Crux
March 1-10, March 30-April 8, April 29-May 8, May 29-
June 7, 2016



Scorpius
June 27-July 6, 2016



Sagittarius
July 28-August 6, 2016, August 25-September 2, 2016



Crux
September 22-October 1, 2016, October 21-31,
November 20-30, 2016



Orion
December 20-30, 2016



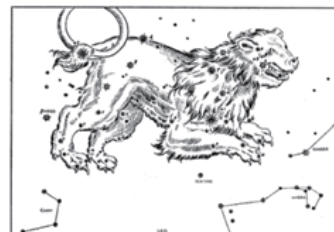
IV Globe at Night 3-2 Globe at Night 활동 방법



Leo
March 30-April 8, April 29-May 8, 2016

The Mythology of Leo

Can you find Leo?



IV Globe at Night 3-2 Globe at Night 활동 방법

Steps to Observe

1. Note your latitude, longitude, date & time
2. Find the constellation Leo ; note sky conditions
3. Match night sky to a magnitude chart
4. Report your observations on-line
5. Compare your observation(s) to thousands around the world

활동 가이드 : 관측 일지
www.globeatnight.org
2015 사자자리 캠페인 날짜 : 4월 9-18 & 5월 9-18

* 표시가 있는 것을 기록하세요.

*월: _____ *일: _____ *년도: _____
*관측 시간: _____ PM 현지 시간 (HH-MM) *도시: _____
*위도 (도/분/초) _____ (북 / 남) 천구 방향
*경도 (도/분/초) _____ (동 / 서) 천구 방향
장소에 대한 설명 (예 : 50m이내의 거리에 불빛이 있어 시야에 방해가 되었다.)

www.globeatnight.org/report.html

활동 가이드 : 관측 일지

www.globeatnight.org

2015 사자자리 캠페인 날짜 : 4월 9-18 & 5월 9-18.

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*위도 (도/분/초) _____ (북 / 남) 천구 방향
*경도 (도/분/초) _____ (동 / 서) 천구 방향
장소에 대한 설명 (예 : 50m이내의 거리에 불빛이 있어 시야에 방해가 되었다.)



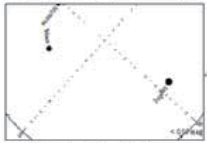
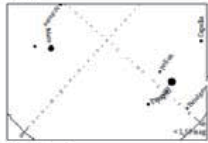
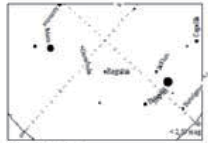
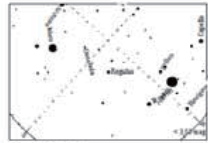
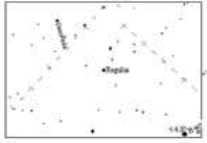
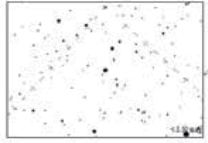
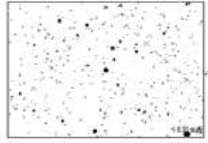
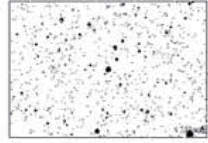
Sky Map [4+]
Mobius Entertainment >
App 내 구입 가능

열기



GLOBEATNIGHT

***밤하늘의 별과 광도 차트 일치시키기:**

			
○ 별이 보이지 않음	○ 광도 1	○ 광도 2	○ 광도 3
			
○ 광도 4	○ 광도 5	○ 광도 6	○ 광도 7

Unihedron Sky Quality Meter의 등급 (선택 사항): _____
 Unihedron Sky Quality Meter의 고유번호 (선택 사항): _____

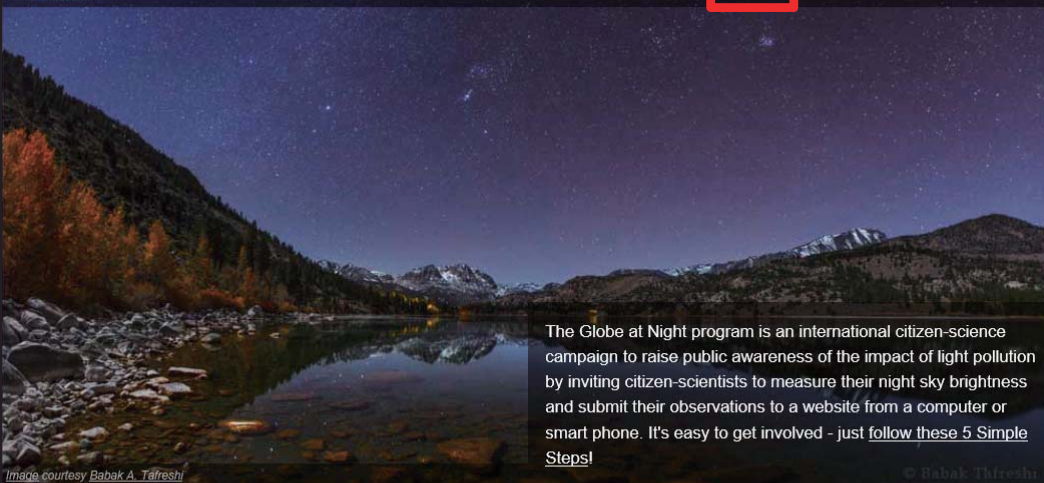
***하늘의 구름 평가:**
 맑음 하늘의 %정도 덮음 하늘의 %정도 덮음 하늘의 %이상 덮음

하늘의 상황 설명 (예 : 북쪽에 안개가 조금 있음):

www.globeatnight.org/report.html

GLOBEATNIGHT

Globe at Night About Learn Observe **Report** Maps & Data Resources



The Globe at Night program is an international citizen-science campaign to raise public awareness of the impact of light pollution by inviting citizen-scientists to measure their night sky brightness and submit their observations to a website from a computer or smart phone. It's easy to get involved - just follow these 5 Simple Steps!

Image courtesy Babak A. Tafreshi © Babak Tafreshi

Join us for the April, 2015 campaign!

Citizen scientists from around the world have

Globe at Night webapp
 The April 2015 campaign is coming soon! Whether you use a smartphone, tablet or computer, [you can submit your data in real](#)

GLOBEATNIGHT

Globe at Night

1 When did you make your observations?

Observation Date (yyyy/mm/v3d)

Observation Time (24 hour time)

[Switch to Daytime version](#)

2 Where did you make your observations?

[Map It!](#)

Location correct: [Reset GPS](#)

Latitude: 36.6286334
Longitude: 127.45755020000001
Elevation: 60.19 meters

3 How dark was the sky that night?

Constellation: Leo

4 What were sky conditions like that night?

Google 이용약관

Location correct: [Reset GPS](#)

Latitude:
Longitude:
Elevation: meters

Country:

Location comments
(E.g., Rural, suburban, or urban location; Snow cover? Number of streetlights, porchlits or other light sources (vending machines, etc.) in vicinity; Trees or structures in vicinity)

4 What were sky conditions like that night?

Clear
 ¼ of the sky
 ½ of the sky
 More than ½ of the sky

Sky condition comments *(E.g., Haze - direction? Clouds - type, direction? Sky glow/light dome - direction?)*

5 Did you use a Sky Quality Meter (SQM)?

SQM reading

Serial Number

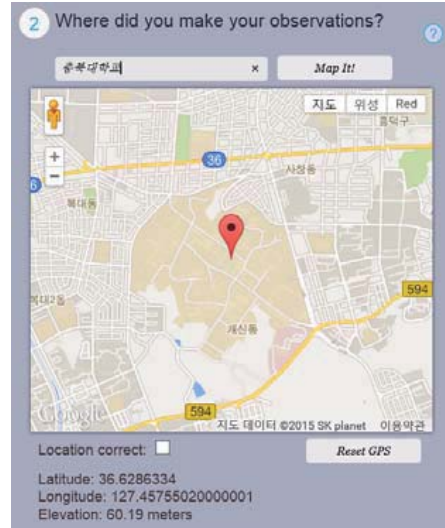
6 Ready to send us your data?

IV Globe at Night 3-2 Globe at Night 활동 방법



Sky Map 4+
Mobius Entertainment >
App 내 구입 가능

+ 열기



IV Globe at Night 3-2 Globe at Night 활동 방법



Loss of the Night

IYL Dark Sky Meter



V 활동 계획

- ▶ Globe at Night 등을 활용한 다양한 체험 프로그램 개발
- ▶ 천문대 및 교육시설에 체험프로그램 진행 및 강의안 제공





International Workshop on Night Sky Brightness Measurements

May 2~3, 2016 Chungbuk National University, Korea



Session II : Measurements of the Night Sky Brightness

Chair: Yonggi Kim (CBNU)

- 14:00 - 14:30 Jason PUN (Universtiy of Hong Kong, Hong Kong)
Performance and Results from the Globe at Night - Sky Brightness Monitoring Network
- 14:30 - 14:45 Hong-Kyu Moon (KASI, Korea)
The Heritage of IYA2009 Korean National Node: Nation-wide GaN Network
- 14:45 - 15:00 Seo-gu Lee (KASI, Korea)
Ten Years of KASI's Activities on Dark Skies Awareness
- 15:00 - 15:15 Je Hoon (Yeongyang Firefly Astronomical Observatory, Korea)
Measurement of the Korean Night Sky Brightness using SQM
- 15:15 - 15:30 Joh-Na Yoon (Chungbuk National University, Korea)
Accuracy analysis of SQM with SkyCCD data of CBNU observatory





Globe at Night - Sky
Brightness Monitoring
Network

International Workshop on Night Sky Brightness Measurements

Performance and Results from Globe at Night - Sky Brightness Monitoring Network

Dr Jason Pun

The University of Hong Kong

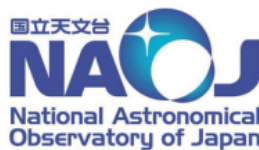
Chungbuk National University, Korea

2.5.2016



The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

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



2

International Workshop on Night Sky
Brightness Measurements
Korea, 2.5.2016



Globe at Night - Sky
Brightness Monitoring
Network



The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Endorsed by the IAU Executive Committee Working Group for the International Year of Light 2015 as a major Cosmic Light program
- Establish a worldwide night sky brightness monitoring network
- In the award letter, “Suggestions were to *“coordinate ... with others who are pursuing the educational aspect in other regions.”*”
- **You are all welcomed to join!**



INTERNATIONAL
YEAR OF LIGHT
2015

**COSMIC
LIGHT** IAU

3

International Workshop on Night Sky
Brightness Measurements
Korea, 2.5.2016



Globe at Night - Sky
Brightness Monitoring
Network



The Globe 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

4

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Brightness Measurements
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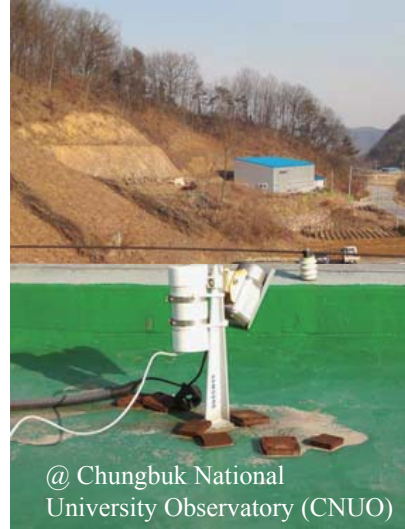


Globe at Night - Sky
Brightness Monitoring
Network



The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Methodology and highlights:
 - Standardized observing method:
 - SQM-LE
 - Reasonable cost and sturdy
 - Standard housing by manufacturer
 - Minimize inconsistency in optical window attenuation
 - 30 seconds sampling interval
 - Standardized calibration scheme



@ Chungbuk National University Observatory (CNUO)

5

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Globe at Night - Sky Brightness Monitoring Network



Sky Quality Meter – Lens Ethernet (SQM-LE)



Figure source: UniLedron

- Manufacturer: UniLedron (Canada)
- Light sensor: TAOSTSL237 High-Sensitivity Light-to-Frequency Converter
- Near-IR blocking filter: Hoya CM-500
- Size 3.6 x 2.6 x 1.1 in.
- Operates from 5-6V DC adapter
- Night sky brightness given in unit mag arcsec⁻²
- Accuracy of ± 0.1 mag arcsec⁻²
- Calibrated by the manufacturer before shipment

6

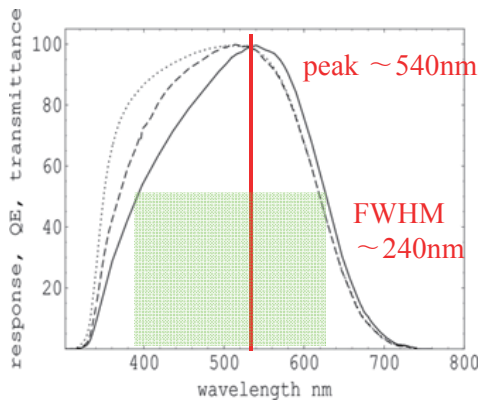
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Globe at Night - Sky Brightness Monitoring Network

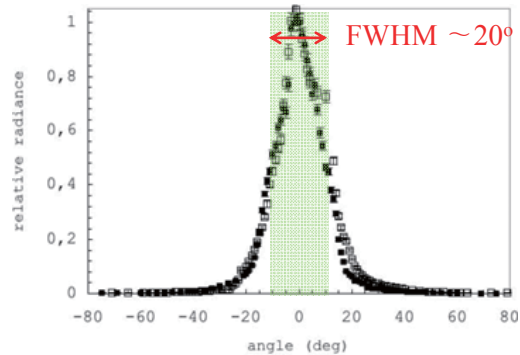


Detector characteristics of SQM



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

(Cinzano 2005)



Angular response function of SQM-LE

(Cinzano 2007)

7

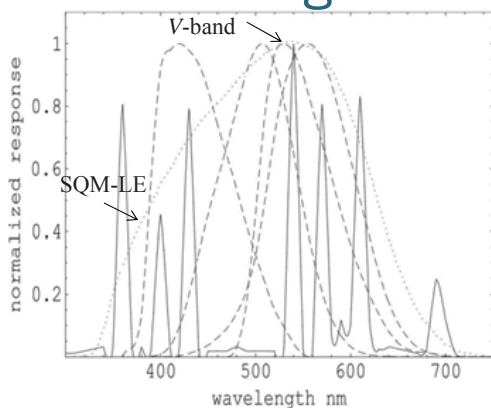
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Brightness Monitoring
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Measuring NSB by SQM-LE



Comparison of **SQM-LE normalized spectral response** (dotted curve) with the spectral curves of Johnson B-band, scotopic, **Johnson V-band**, and photopic (dashed curves from left to right) and the emission spectrum of a mercury vapor lamp (solid curve) (Cinzano 2005)

- Compare photometric Johnson V-band vs SQM-LE response:
 - FWHM:
 - SQM-LE: 240 nm
 - V-band: 84 nm (Bessell 2005)
 - Peak:
 - SQM-LE: 540 nm
 - V-band: 545 nm (Bessell 2005)
- The offsets between V-band and SQM-band:
 - Depends on sky spectrum and cloud condition
 - 0 - 0.25 mag arcsec⁻² (Cinzano 2005)
 - Up to 0.6 mag arcsec⁻² when cloudy (Puschign et. al. 2014)

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International Workshop on Night Sky
Brightness Measurements
Korea, 2.5.2016



Globe at Night - Sky
Brightness Monitoring
Network



The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Methodology and highlights:
 - Data
 - **Live display** of NSB on Google Maps
 - **Full sharing** of data among participating 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

9

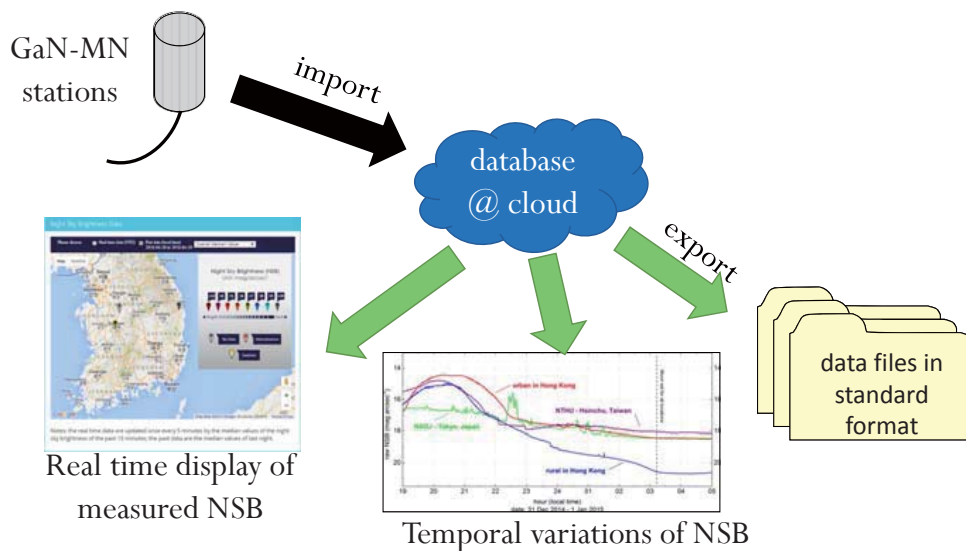
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Globe at Night - Sky Brightness Monitoring Network



GaN-MN night sky brightness (NSB) database: data flow



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Globe at Night - Sky Brightness Monitoring Network



The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- GaN-MN status report:
 - Demonstrated that we can indeed establish a **global network of night sky brightness data collection**
 - Efficient network setup: less than one week between SQM being online and real-time data collection in most cases
 - Very few errors attributed to the GaN-MN data collection system.

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Globe at Night - Sky
Brightness Monitoring
Network



ESRI
기초과학연구소

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- GaN-MN currently has:
 - 16 stations operating in 8 countries/regions in 3 continents
 - 3 stations in operation in Korea
 - Over eleven million individual measurements had been collected by May 2016.

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Brightness Measurements
Korea, 2.5.2016



Globe at Night - Sky
Brightness Monitoring
Network



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기초과학연구소

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Current stations (more on next page):

Organization	Country /region	Operational date
Taipei Astronomical Museum (TAM)	Taipei, Taiwan	2014-11-19
National Astronomical Observatory of Japan (NAOJ)	Tokyo, Japan	2014-12-19
The University of Hong Kong (HKU)	Hong Kong	2014-12-26
National Tsing Hua University (NTHU)	Taiwan	2014-12-30
Yeongyang Firefly Astronomical Observatory (YFAO)	Yeongyang, Korea	2015-01-24
Chungbuk National University Observatory (CNUO)	Cheongju, Korea	2015-01-27
Lulin Observatory (LUO)	Taiwan	2015-03-27
Ho Koon Nature Education cum Astronomical Centre (HKn)	Hong Kong	2015-04-18

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Current stations (con't):

Organization	Country /region	Operational date
South African Astronomical Observatory, Cape Town (SAAO)	South Africa	2015-07-28
Kuzuha Observatory (KuO)	Japan	2015-08-01
National University of Mongolia (NUM)	Ulan Bator, Mongolia	2015-08-05
Zselic Starry Sky Park (ZSSP)	Hungary	2015-08-24
Hungarian Astronomical Association (Bar)	Hungary	2015-09-11
Elsterland-Observatory (ELO)	Germany	2015-09-25
Nagasaki Nishiyama Observatory (NNO)	Japan	2016-03-19
Daejeon Astronomical Observatory (DAO)	Daejeon, Korea	2016-03-20

Red: current stations (16 as of Apr 2016)

Blue: potential stations (3 as of Apr 2016)



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GaN-MN in Korea



충북대학교 천문대
Chungbuk National University Observatory



대전시민천문대
Daejeon Astronomical Observatory



충주고구려천문과학관
Muju Astronomical Observatory



영양군 자연생태공원관리사업소
반딧불이담당 박제훈
Yeongyang Firefly Astronomical Observatory

The GaN-MN night sky brightness database

- All NSB data collected from GaN-MN stations fed to a MySQL database automatically and instantaneously
 - **Full sharing of data** among participating stations
- Participants access data archive through a user-friendly web-based interface

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Public Interface of GaN-MN

<http://globeatnight-network.org/map.html>



- A light pollution map based on [Google Map](#) platform:
 - Real-time data displayed for locations currently at night time
 - Median value of NSB from the previous night for locations currently at day time

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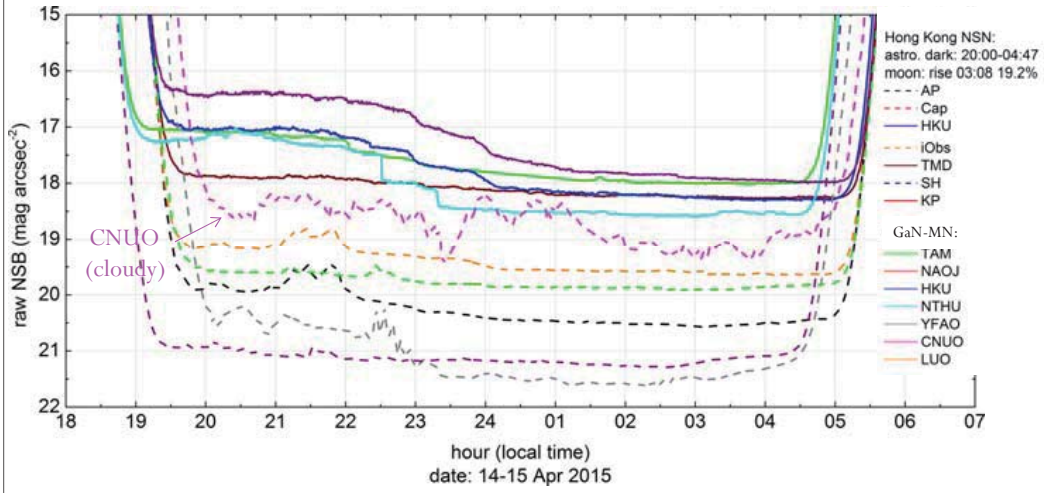
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Early performance of GaN-MN – nightly trends (preliminary analysis)



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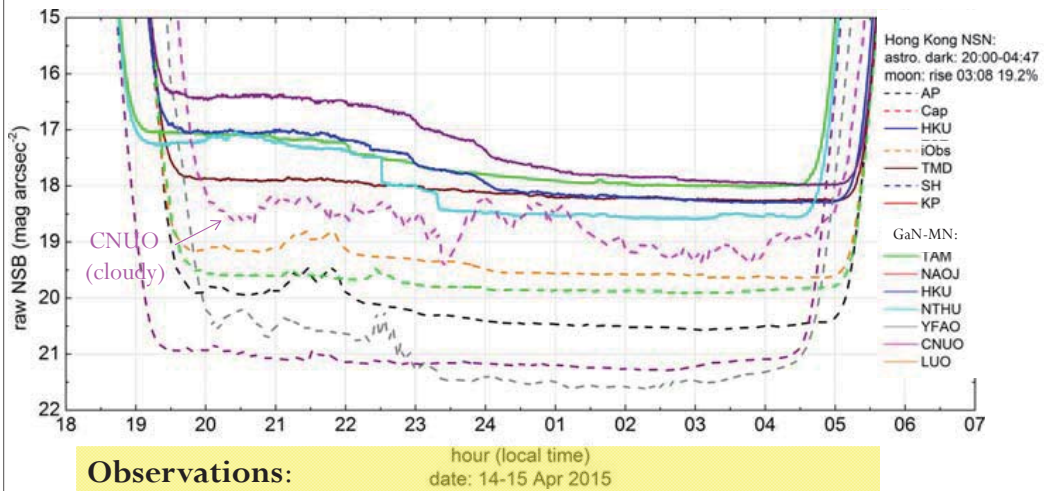
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Globe at Night - Sky
Brightness Monitoring
Network



Early performance of GaN-MN – nightly trends (preliminary analysis)

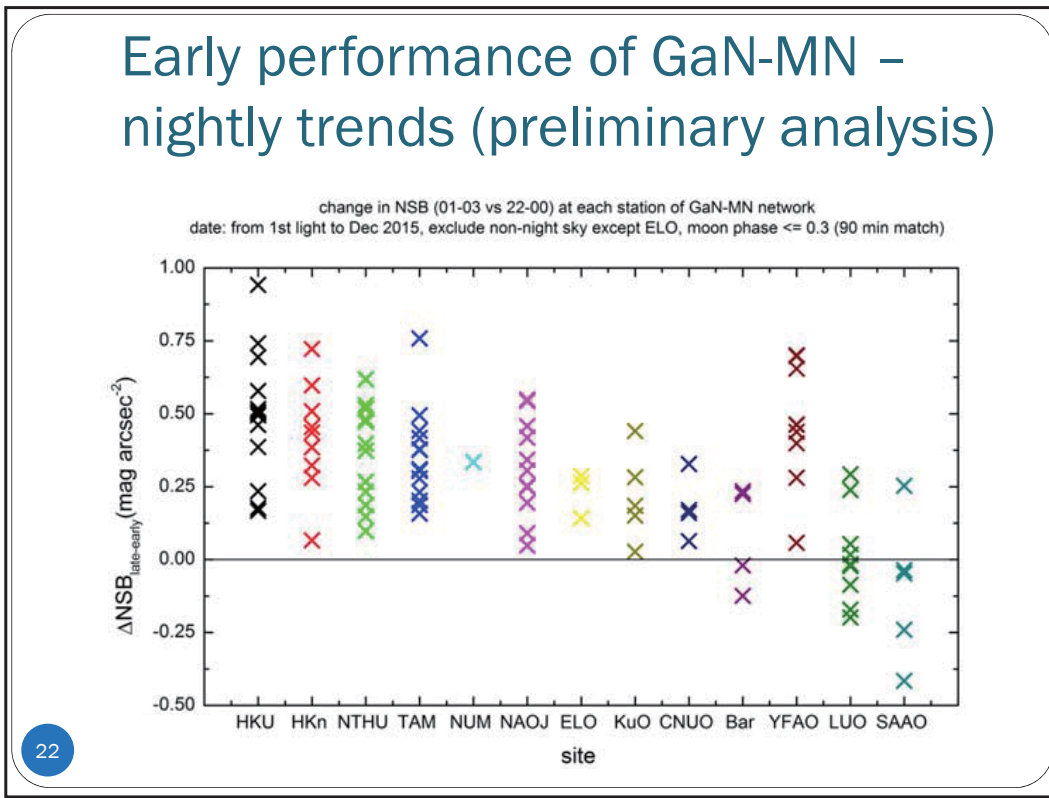
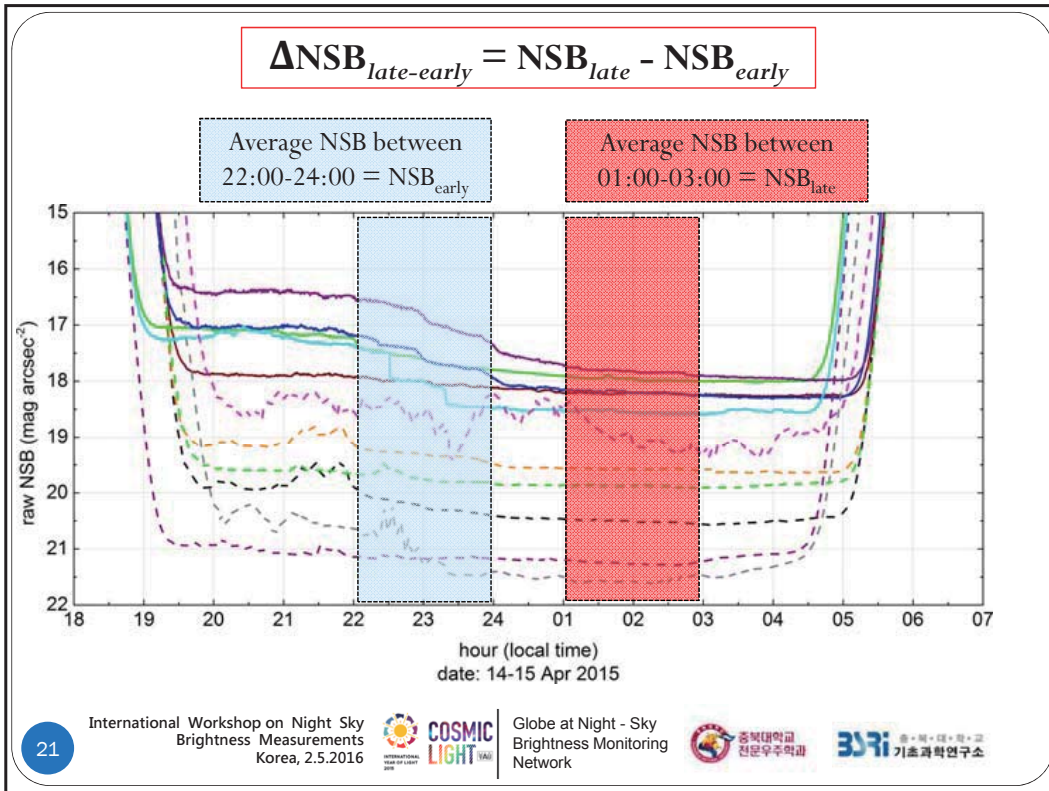


Observations:

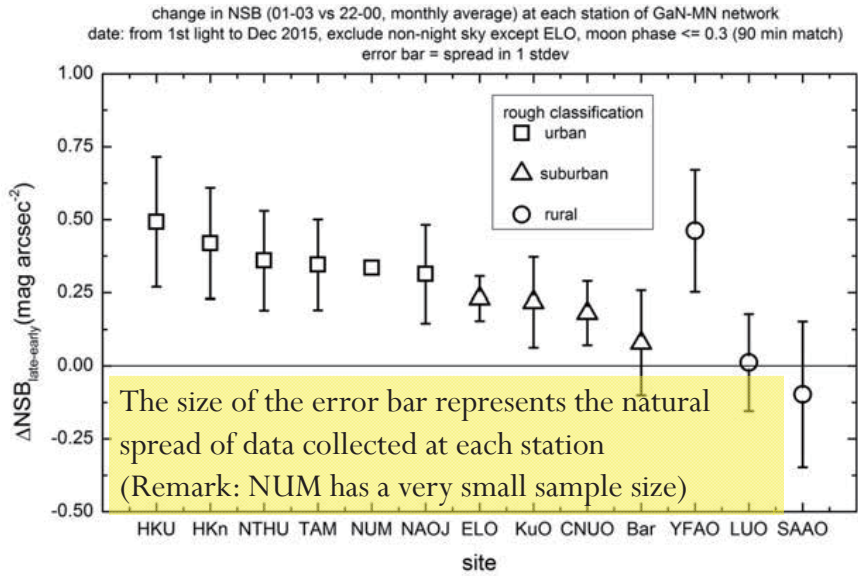
The sky is generally darker in late night.

Urban stations are brighter than suburban and rural stations.

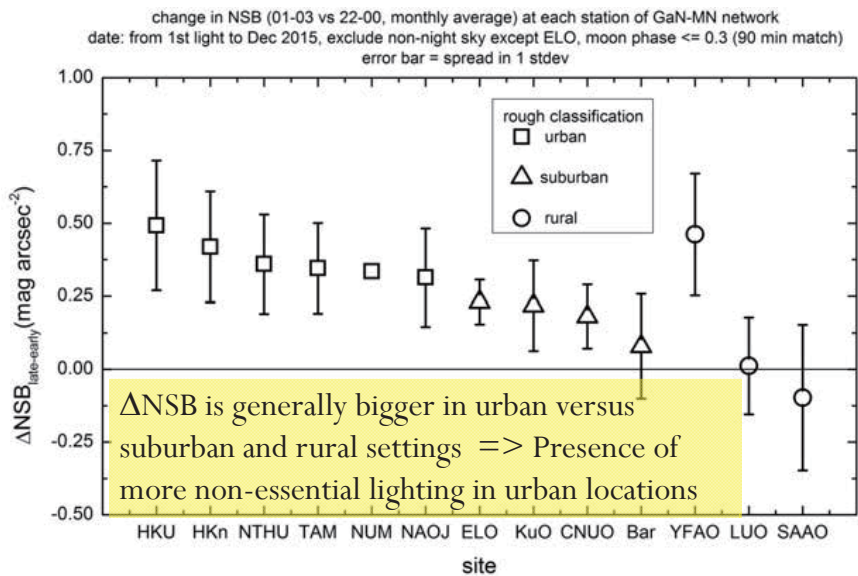
20



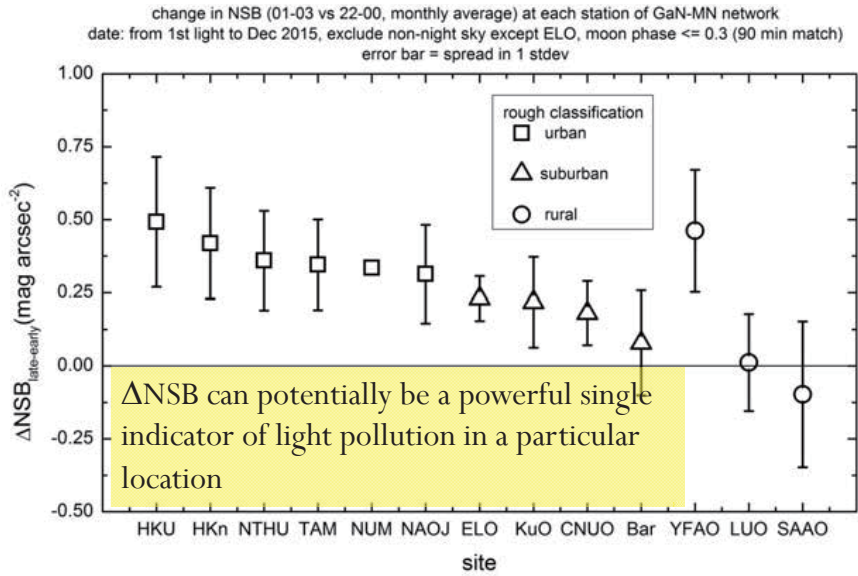
Early performance of GaN-MN – nightly trends (preliminary results)



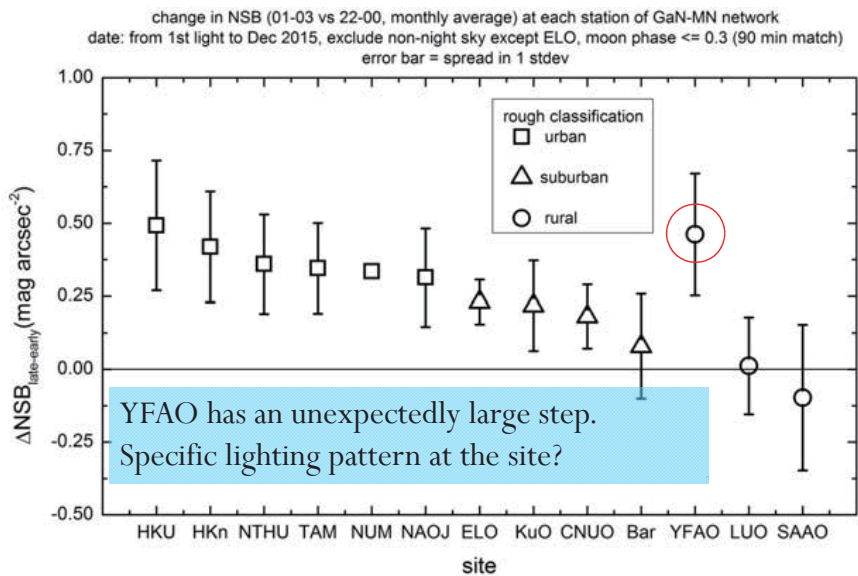
Early performance of GaN-MN – nightly trends (preliminary results)



Early performance of GaN-MN – nightly trends (preliminary results)



Early performance of GaN-MN – nightly trends (preliminary results)



The Globe 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

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Brightness Measurements
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Globe at Night - Sky
Brightness Monitoring
Network



The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

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 - **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

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Brightness Measurements
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Globe at Night - Sky
Brightness Monitoring
Network



The Globe 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
 - Let's fight light pollution together!

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Brightness Measurements
Korea, 2.5.2016



Globe at Night - Sky
Brightness Monitoring
Network



충북대학교
천문우주학과

ERI
충·북·대·학·교
기초과학연구소

Thank you!

For more information on the GaN-MN,

- 1) Visit: <http://globeatnight-network.org/>
- 2) Email us at: globeatnight.network@gmail.com or
gan-mn@qq.com

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Korea, 2.5.2016



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천문우주학과

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기초과학연구소

Heritage of IYA Korean Nat'l Node: Nation-wide GaN Network

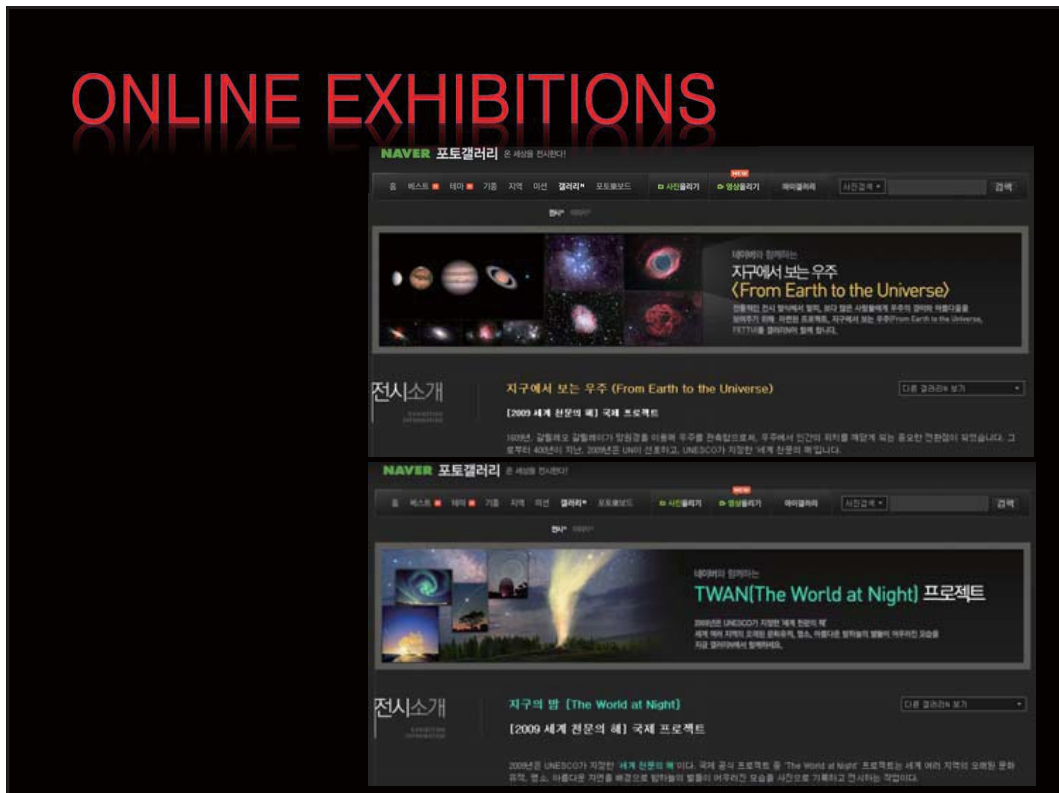


Hong-Kyu Moon

Korea Astronomy and Space Science Institute

IYA 2009 in Korea





TURN-OFF THE LIGHTS TURN-ON THE STARS



HOW MANY STARS?

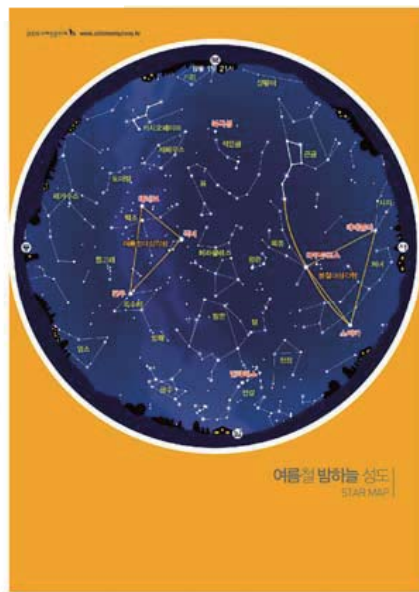
How Many Stars?
별은 얼마나 많을까요?

한 세계 어디서든 보일지라도, 그리고 보이지 않는 천정사파의 빛공해(Light Pollution) 수준을 측정, 비교하고 평가하여 대한 광천문 협회(KAIST)가 주최한 이번 행사에 참가합니다.

○ 행사 참여방법

- 1. 행사 주제를 둘러싸고 "어둠을 사랑하는 밤"을 외칠 수 있습니다.
- 2. 행사 현장에 제공된 별의 지도를, 자신이 볼 수 있는 한 별을 찾아서 외쳐 부르거나 읽고, 그 별에 관심을 갖게 됩니다. 이렇게 세 별을 연결하면 "어둠을 사랑하는 밤"이 됩니다.
- 3. 별이 아닌 것, 천정으로 보이는 별이 아닌 것만 비슷한 그림(4면의 별을 선에서 따와)에 붙이는 4대 별 찾기, 달이 안 보이면 천정(천정)을 보아서 별의 위치를 알려주는 4대 별 찾기.

www.energyday.org





4 HUNDRED ASTRONOMICAL TELESCOPES

2009 대한민국 별축제

“천체망원경 400대로 떠나는 400년 시공여행”

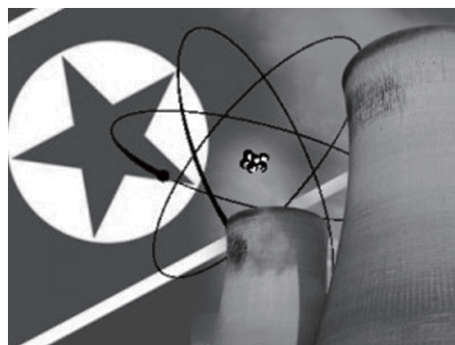
400년 전, 갈릴레이가 처음 망원경을 통해서 바라본 태양과 달, 목성과 은하수를
400대의 천체망원경으로 직접 본다.

일시: 2009년 10월 31일 14:00 ~ 22:00 / 장소: 서울 올림픽공원 평화의 광장

“천체망원경 400대” 참여 기관: **세명대학교 홈페이지** (www.astronomy2009.kr) 참고.

1. 알제르르프로그램 2. 태양, 안, 달, 목성 상을, 삼단
3. 목성상인 2와 3. 자외 천체망원경 4. 천체망원경 400대입니다.
5. 학생원리관속 정산제외: 서울-경기, 인천지역에선 6. 지역본부 운영

• 주최: 한국과학창의재단, 기초과학연구원, 국제천문연맹
• 후원: 천체망원경 400대 세계 인원이 해 관측을 지원한다, 한국항공우주연구원
• 후원: 교육과학기술부, 국제천문연맹한국위원회



IYA 2009 DSA Heritages

IYA heritages: Photo exhibition tours in Korea

The Earth at Night = TWAN

COEX, Sejong Cultural Center + 8 Mar 09 – Jan 10

From Earth to the Universe = FETTU

38 Public places Mar 09 – Jan 10

NAVER On-line Exhibition

TWAN Mar 09 – Mar 10

FETTU Sep 09 - Dec 09

Starry Night

14 places Mar 09 – Jan 10

Digital Universe

6 KTX Stations Sep – Dec 09

The Korea at Night

Sejong Cultural Center + 2 Jul – Sep 09

Aurora Photo Exhibition

COEX + Lotte Department Store Jan – Feb 10

IYA heritages: DSA-related activities in Korea

Earth Hours Changwon, Mar 28 '09

How Many Stars? 12 places, April 2-3 '09

Sky Quality Measurement Campaign

64 places, Jul-Nov '09

Public Hearing on Light Pollution Protection Law

National Assembly, Aug 19 '09

Turn off the Lights, Turn on the Stars!

Seoul Square and 7 places, Aug 19 '09 (cancelled)

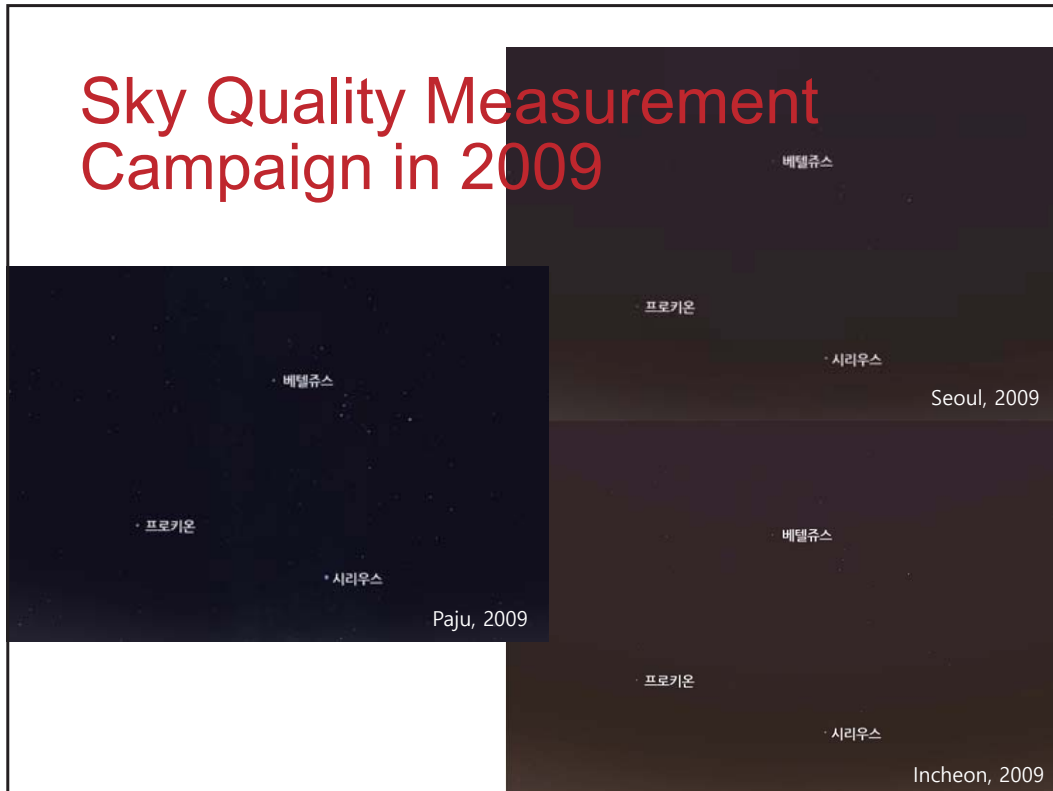
* **Starry Night** LG Global Challenger, CNU std.

* **Trapezium** Ministry of Welfare, college + high school std.

* **Dark Sky Lovers** Self supply, Yonsei U std.

The future

Sky Quality Measurement Campaign in 2009



Sky Quality Measurement Campaign

- IAU developed low-cost SQM
- (사)한국천문우주과학관협회 conducts SQ monitor campaign:
The KSSS provides the SQM
- SQ Monitoring report



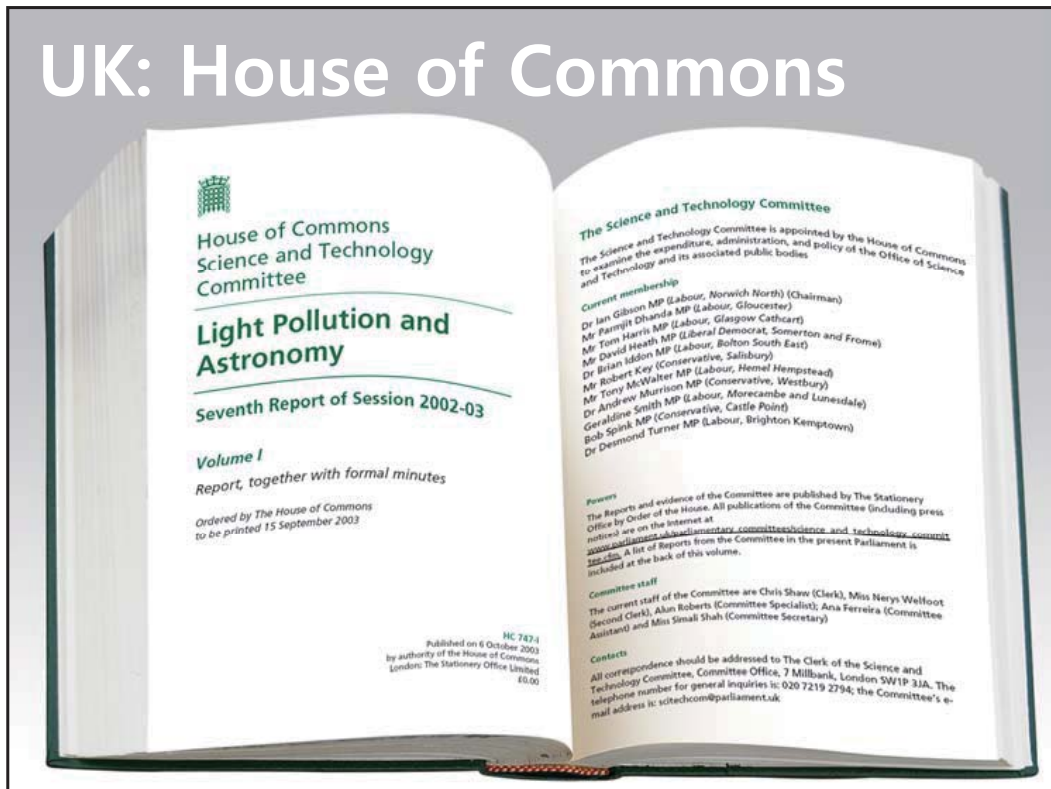
Sze-Ieung Cheung

Backup: A proposal

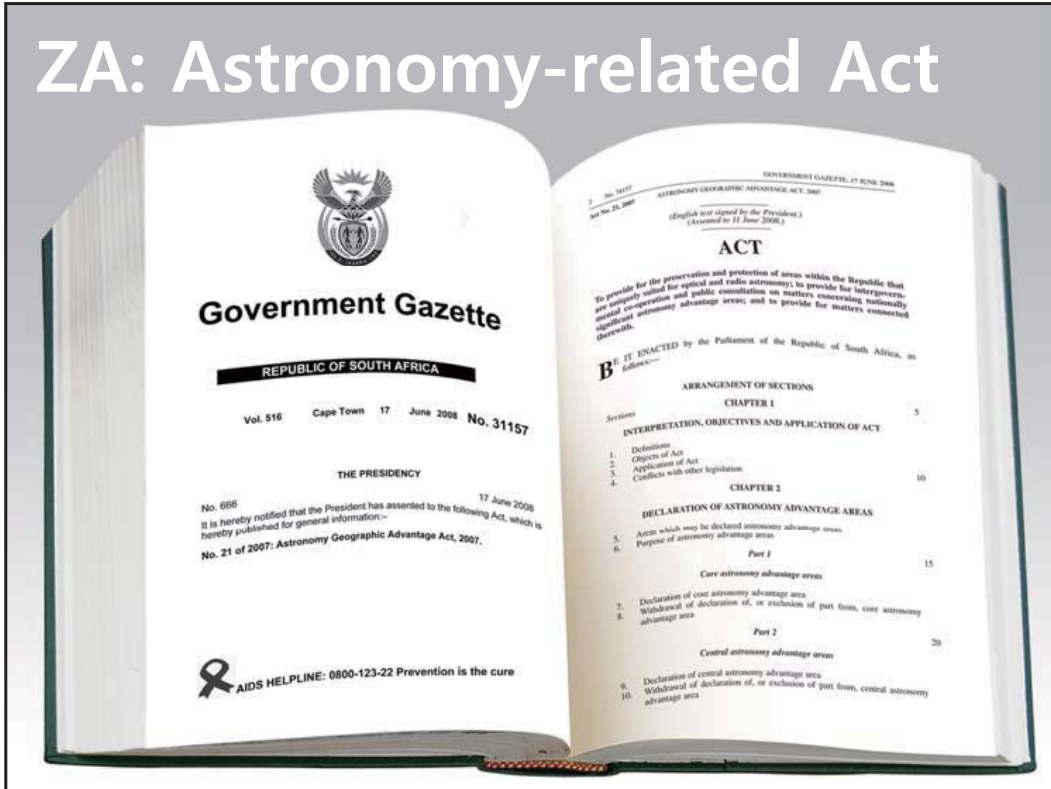


2015 Seoul

UK: House of Commons



ZA: Astronomy-related Act



FORUM AT THE NATIONAL ASSEMBLY

빛공해포럼

2009년 11월 5일 (목) 오후 2시
국회의원회관 소회의실

국회의원 박영아
www.parkyoungah.com

원정부

빛은 물 공기와 함께 생활의 구별이와 불려 수 인식이다.

빛은 식물의 광합성에 꼭 필요하며, 인간의 생리작용을 도와주기도 합니다. 또한, 인공지능의 시공의 활동 안전에 관 한 역할을 얻어 주어 산업화의 기술발전의 상징으로 대거되고 합니다.

그러나 무분별한 인공조명의 사용으로 동식물 등 생태계의 교란과 인간의 신체적 재산적 피해가 증가되는 추세에 있습니다. 이러한 빛공해를 더 이상 방치하지는 않겠습니다.

이에 따라, 지난 9월 9일 '빛공해방지법'이 국회에 발의 되었으며 앞으로는 빛공해에 대한 체계적인 관리의 과제를 통해 생태계 피해예방과 국민의 쾌적한 생활을 조성이 가능해지리라 기대합니다.

이번 빛공해 포럼을 통해 우리나라의 인공조명 및 도시를 살펴보고 제도적 개선방안을 마련하고자 합니다. 보다 철저해서서 좋은 의견을 제시하여 주시고 많은 관심과 격려를 부탁드립니다.

국회의원 **박영아**
원정부 장관 **이민이**

도움말

인사말

박영아 국회의원
오준국 환경부 환경보건정책관

발

부산과 국토지리의 빛공해 등에
김정태 경희대학교 지속가능건축기술 연구센터장

빛공해 방지를 위한 서울시 조명관리 방안
이영기 서울특별시 환경에너지안전팀장

빛공해 방지 정책방안
이영기 환경부 생활환경과장

주최

국회의원 박영아
원정부 장관 이민이

Additional slides

Webzine

INTERNATIONAL YEAR OF ASTRONOMY 2009

IYA2009

- 인사말
- 비전과 목표
- 한국조직위원회
- 로드맵
- 자료실
- 참여 방법
- 참여 국가

PROJECT

- 국내프로젝트
- 국제프로젝트

IYA 2009
2009 세계 천문학의 해

인사말
GREETINGS

“2009 세계천문의 해에 대한 많은 관심 감사드립니다.”

2009 세계 천문학의 해 한국조직위원회 인사말

400년 전, 피렌체에 살았던 갈릴레오 갈릴레이는 관건무결한 줄 달았던 태양에 유경이 있으며, 달이 마코합기는가년 울을 불을한 지점으로 뒤달었다는 것, 작은 달들이 목성을 공전할 뿐 아니라, 목성에 구가 달한다는 사실을 처음 알았습니다. 천학수가 날 별들르 이루어졌다다는 것도 그 차은 앙찰광을 통하서 밝혀난 사실입니다.

알릴레오 후강 이후 천문학은 비약적인 발전을 거듭했습니다. 우리 천학는 특질적인 법의 집합이며, 이러한 천학가 무수히 달다는 것, 우주에 시초가 있었으며, 한라 정찰하고 있다는 사실들이 그것입니다.

갈릴레이가 아니었다라면 17세기 이후 천문학이 과연 어떤 방향으로 출라가게 되었을까 하고 뒤질어 보지 않을 수 없습니다.

국제천문연맹과 유네스코는 천체달일경 400주년을 기념하기 위해 2009년을 세계 천문학의 해로 지정하고, 나하은 세계 천문의 해를 선포했습니다. 이어 우리 국회는 세계 천문의 해 지지결의안을 통과시켰으며, 한국은 25개국 속달할 국원국을 건달하는 국가 대열에 신입하게 되었습니다. 이제, 우리 선조들이 이루어한 눈부신 과학 전통의 계승을 기대해 봅니다.

2009 세계 천문의 해 한국조직위원회에서는 넉넉노스 모두가 즐길 수 있는 다채로운 프로그램을 준비하고 있습니다. 2009년 한 해, 우리 국민들도 세계 최초로 기획된 지구촌 속계를 마음껏 즐길 수 있기를 바랍니다.

2009 세계 천문 디어 한국조직위원회 주최위원회
위원장 김성환
위원장 김성환
위원장 김성환

2009 세계천문학의 해

신문을림피이드

IYAZINE

- 공지사항
- 행사일정
- 기사를들
- 기획집합
- 미디어 걸러리
- 이웃의 천체 사진
- 이달의 별야행 사진
- 동양산 여행리버
- IYAZINE 편집국

KV 한국천문연구원

Google Search 검색

RSS



Ten Years of KASI's Activities on Dark Skies Awareness

-Turn OFF the LIGHT and Turn ON the STAR

Seo-Gu Lee sglee@kasi.re.kr
Korea Astronomy and Space Science Institute

KASI- Korea Astronomy and Space Science Institute



Established in 1974

National Astronomical Observatory

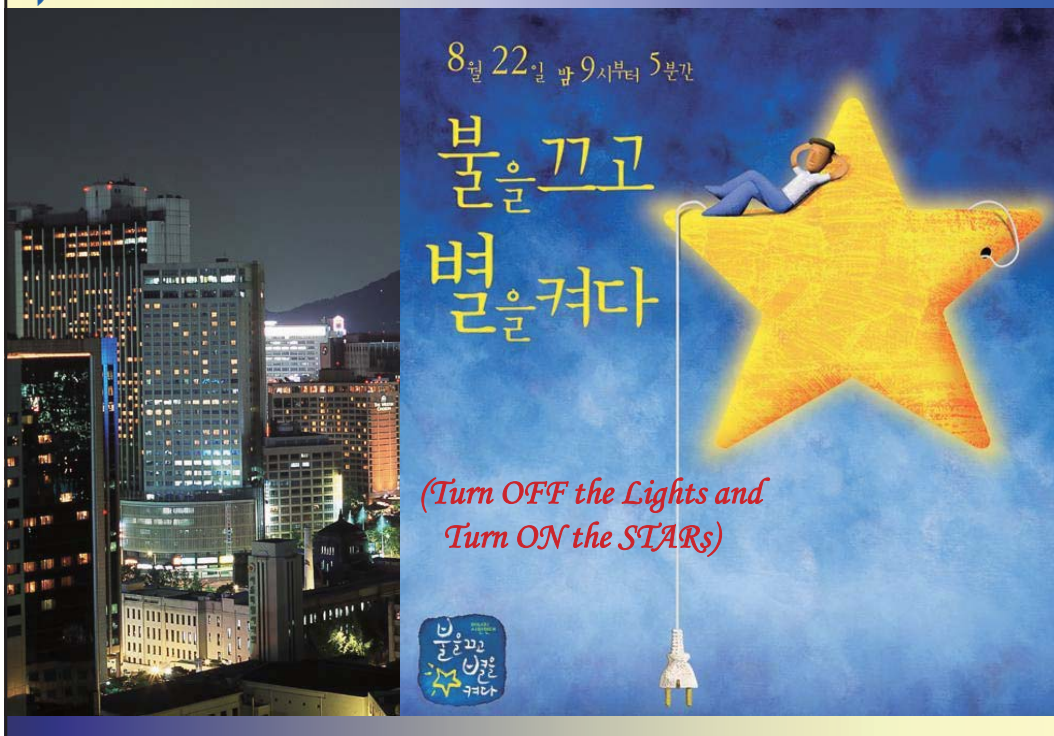
Astrophysics, Optics, Radio, Space Science, GNSS

KASI's Public Outreach

- Hosts 'Astrofest' for the public
- Provides educational programs to school teachers
- Organizes 'Astro-photo Contest'
- Issues calendars with description of important astronomical events

• Korea NGO's Energy Network

- Consists of 270 environmental, consumer and women's groups throughout the country
- Activities to spread energy saving and energy efficiency products.
- Energy Day – 22nd Aug.
 - Maximum Electric power consumption day in Korea
 - Designated at 2004
- Power off the Air Conditioner for an hour at 2 pm
Turn off the light for 5 min. at 9 pm



22nd Aug. 2007.(wed) (10th July of Lunar calendar)
9pm

- Turn the All Lights Off around City Hall Area.(~ 1km²)
- It includes almost all the lights in Office building, Street Light, Sign Board Lamp and Large Advertisement LED

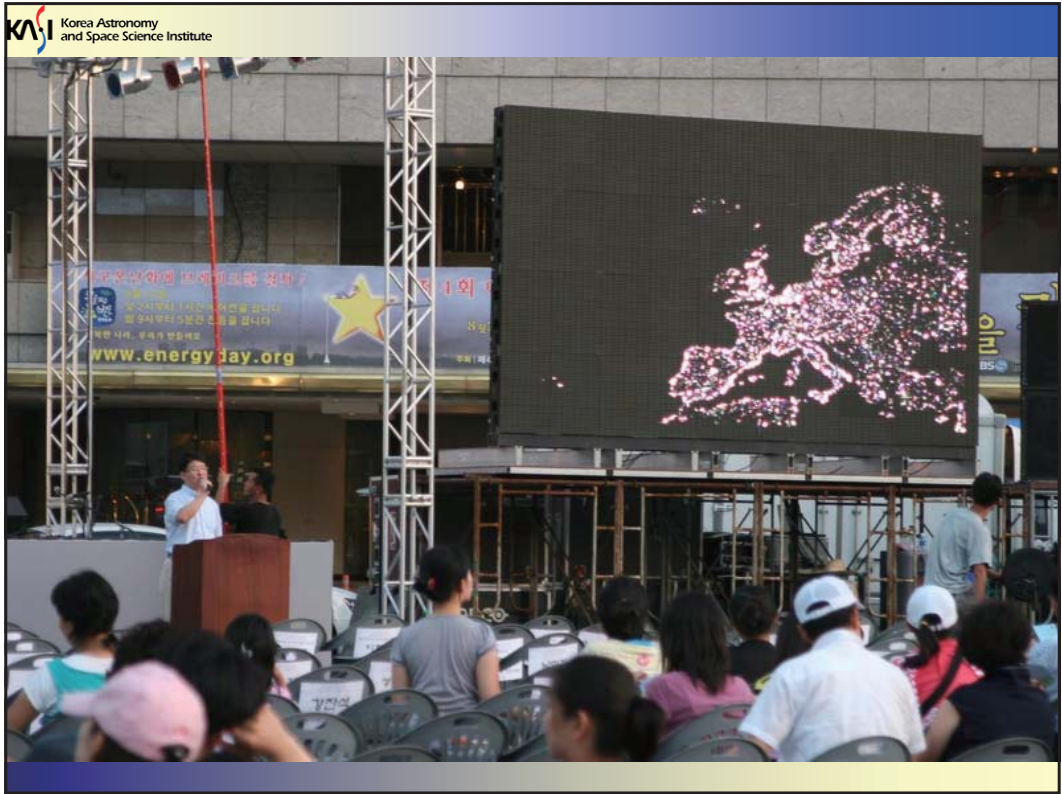
- 6 cities participated the

- Stayed only for 5 min but public got significant
not perfectly dark,

‘The ... Rs’



8th Oct. 2007





8th Oct. 2007

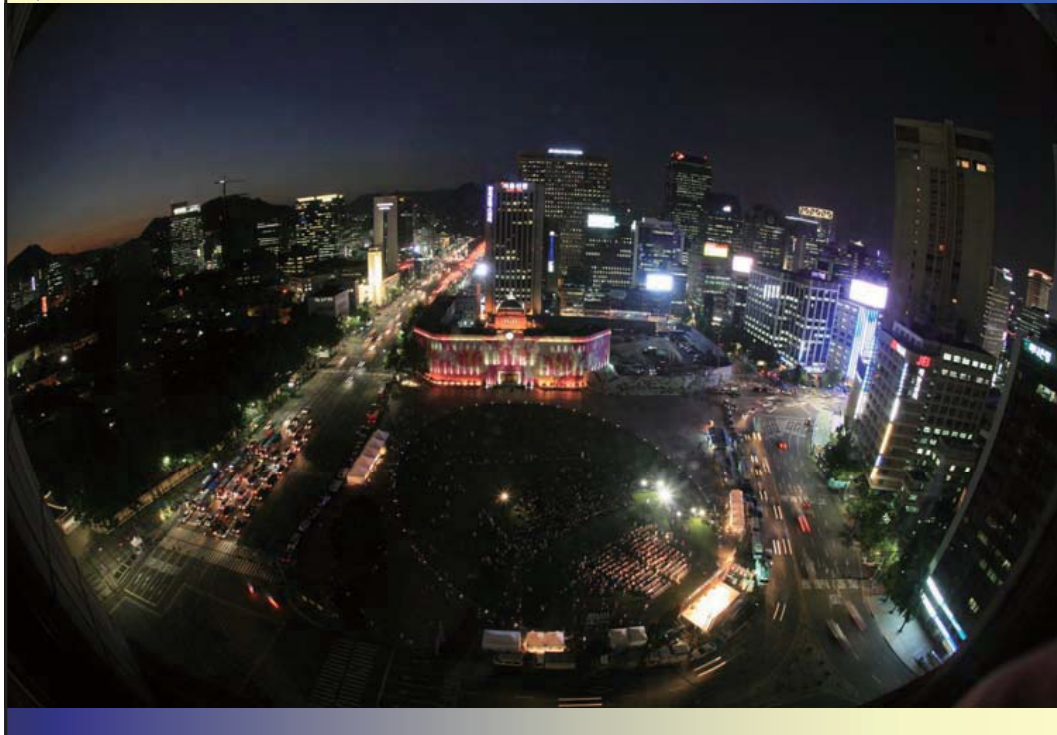
















- **Major effect of campaign**

- **Mayor of Seoul & Officer has awareness of importance of Dark Sky**
 - They are like to built Public Observatory in Seoul.
 - City already has regulation concerning light pollution prevention.
- **Amateur Astronomical Society is getting systematic structure.**
 - 16 divisions are well organize countrywide
- **Public recognizes astronomy as living science.**
 - Many parents has strong interests for visiting observatory

- **KASI will work/support continuously for**

- **International collaboration for**
 - dark sky awareness activities.
 - making worksheet for education.
- **Amateur astronomers**
so they are confident they doing right things.
- **Public people understands**
the pleasure of discovery with astronomy

Let's Make it happen again!

Thank You!.

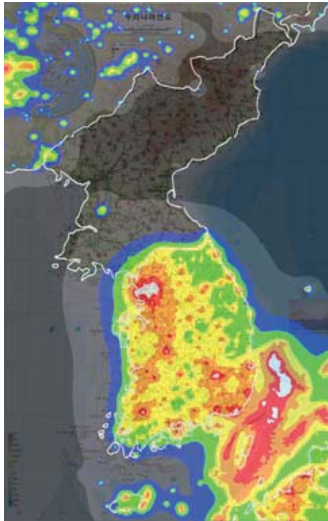
빛 공해 모니터링을 위한 국내 네트워크 구성

대전시민천문대 이용선

목차

- 빛 공해
- 국내 빛 공해 모니터링 네트워크
- SQM-LE 빛 공해 측정장비
- 설치 현황
- 설치 과정
- 관측 데이터

빛 공해



- 빛 공해의 사전적 의미
인간에 의해 발생된, 과잉 또는 필요 이상의 빛에 의한 공해(公害)
침입광, 과도한 조명, 눈부심, 빛의 혼란, 밤하늘의 영향
- 빛 공해로 인한 현상
천체관측의 방해, 생태계 교란, 에너지 낭비, 인체의 바이오리듬, 기타 사회문제
- 대책
공극적으로 빛을 없애면 됨.
⇒ 빛이 하늘로 향하지 않도록 설정(가로등), 불필요한 조명 끄기, 효율적인 조명 관리 계획 수립 및 법(조례) 제정 등.



빛 공해



WHY LIGHT MATTERS					MORE
LEARN ABOUT LIGHT					MORE
HANDS-ON INVOLVEMENT					MORE
COSMIC LIGHT					MORE
LIGHT FOR DEVELOPMENT					MORE

국내 빛 공해 모니터링 네트워크

화천조경철천문대

충주고구려천문과학관

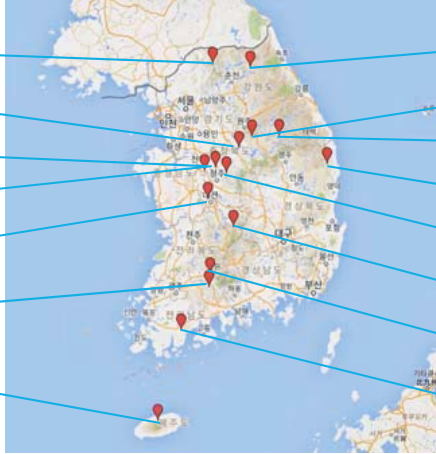
천안홍대용과학관

증평좌구산천문대

대전시민천문대

곡성섬진강천문대

제주별빛누리공원



양구국토정중앙천문대

별새곶돌과학관

영월별마로천문대

영양반딧불이천문대

충북대학교천문대

무주반디별천문과학관

남원 항공우주천문대

장흥군정남진천문과학관

전국15개 기관 참여중

SQM-LE 빛 공해 측정장비



SQM-LE

장비 : Sky Quality Meter – Lens Ethernet (SQM-LE)

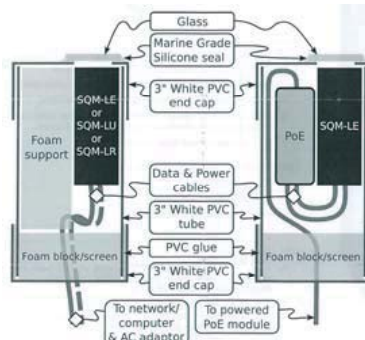
사양

- Ethernet 연결 (LAN으로 연결가능)
- 광센서 : TAOS TSL237 Light-to-Frequency Converter (320 ~ 700nm 파장대의 빛 감지)
- 근적외선 차단 필터 : Hoya CM-500
- 크기 : 3.6 x 2.6 x 1.1 in. (9.1 x 6.6 x 2.8 cm)
- 5-6V DC adapter 사용
- 20° 크기의 원뿔형 빔하늘 밝기 측정
- 측정 단위는 mag arcsec⁻²
- 오차 ±0.1 mag arcsec⁻²의 정확성
- 일몰30분전 부터 데이터가 측정되기 시작하며 일출후 데이터 측정 불가
- 이론상의 데이터는 22등급이 한계

SQM-L : \$134.99US

SQM-LE : \$249.99US, \$289.94US, \$349.94US

<http://unihedron.com/>



설치현황

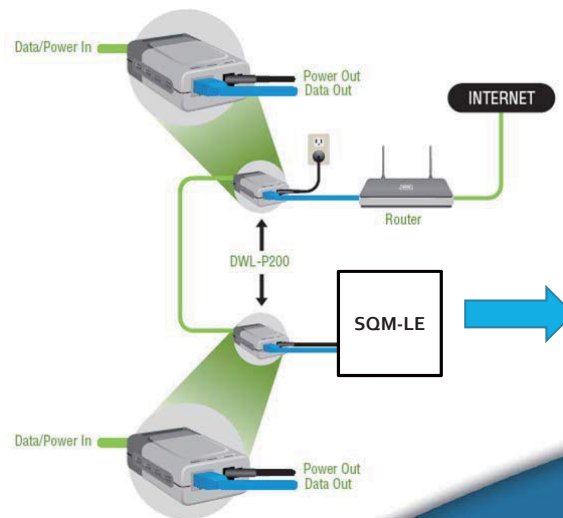
영양 반딧불이 천문대



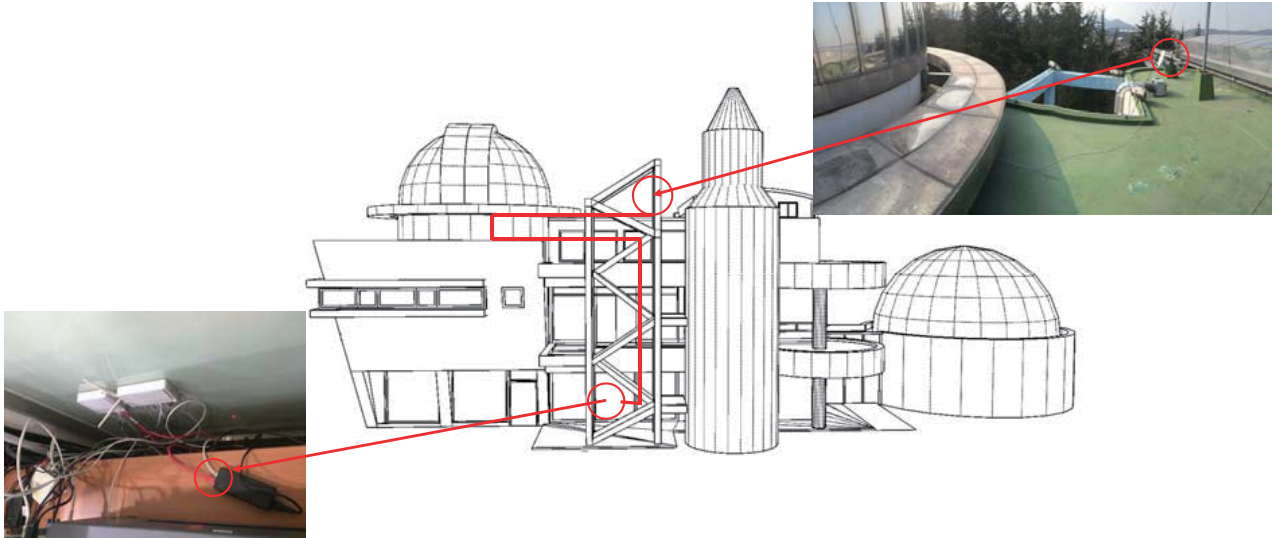
대전시민천문대



설치과정



설치과정



관측데이터

- 밤하늘 밝기에서의 달의 영향

대전시민천문대와 영양반딧불이 천문대의 달이 밤하늘 밝기에 미치는 영향

대전시민천문대의 보름(3/24-3/25)과 그믐(4/5-4/6) 때의 밤하늘 밝기 측정 및 비교

- 날씨와 밤하늘 밝기와의 관계

대전시민천문대와 영양 반딧불이 천문대의 날씨가 밤하늘 밝기에 미치는 영향

대전시민천문대의 맑은날(3/24-3/25), 흐린날 (4/21-4/22), 비오는 날 (4/22-4/23)의 데이터 비교

- 주변환경에 따른 밤하늘 밝기

관람객이 많이 찾아오는 토요일, 주변 행사에 따른 밤하늘 밝기

- 지역에 따른 밤하늘 밝기

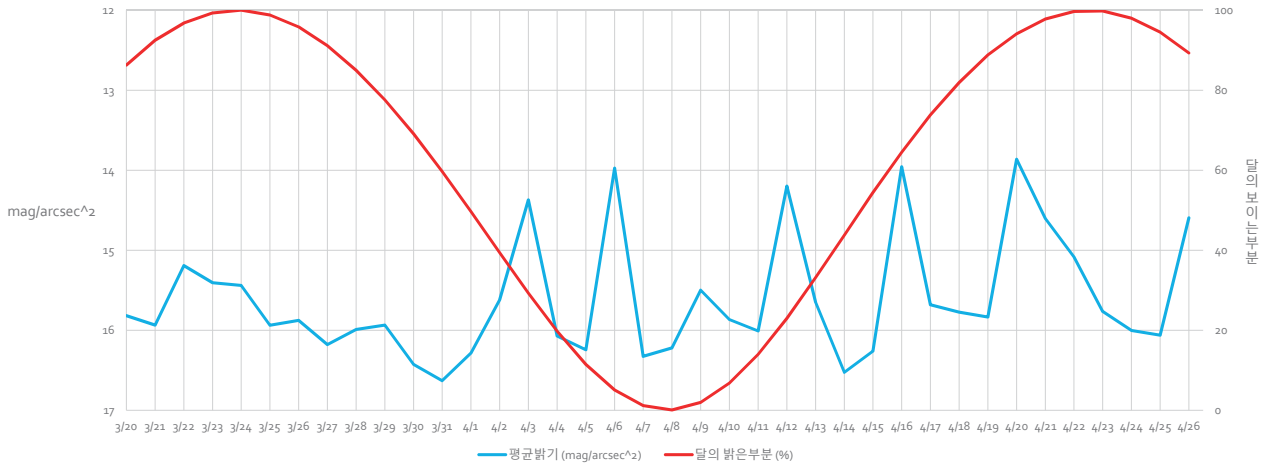
현재 프로그램 참여중인 8개 기관들의 4/5-4/6 데이터

도시: 대전시민천문대, 홍콩대학교, 홍콩 Ho Koon Nature Education cum Astronomical Centre, 일본Nagasaki Nishiyama Observatory, 남아프리카공화국 천문대

외곽: 영양반딧불이 천문대, 헝가리 Zselic Starry Sky Park, 대만 Lulin observatory

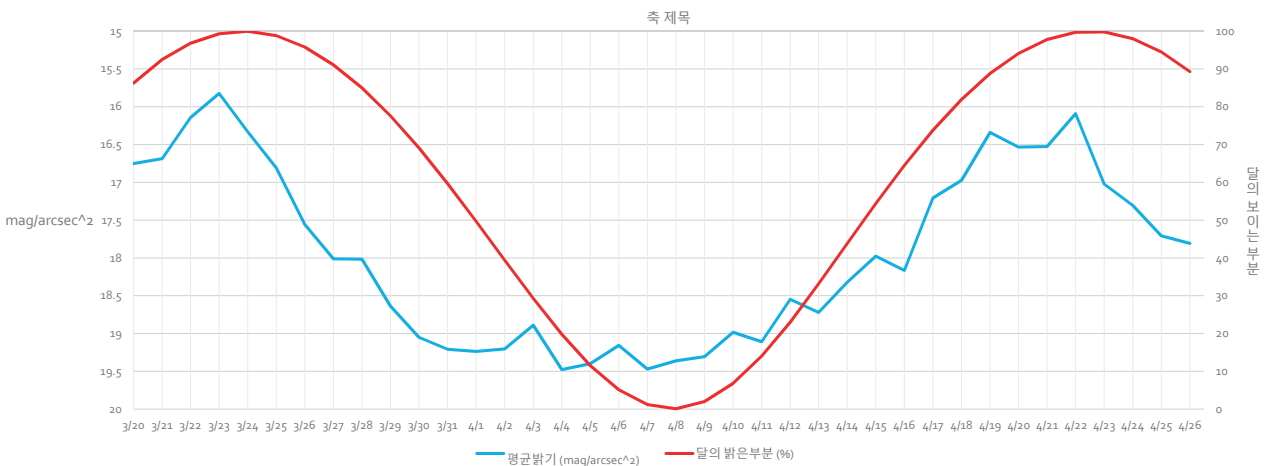
관측데이터 - 달의 영향

대전시민천문대 평균 밤하늘밝기 (3/20~4/26)

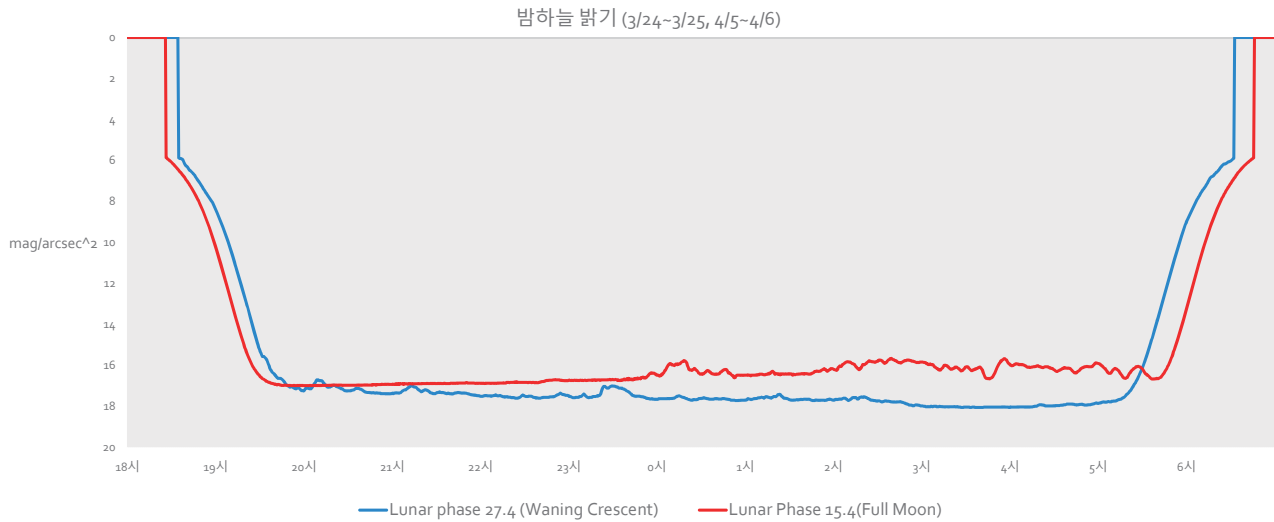


관측데이터 - 달의 영향

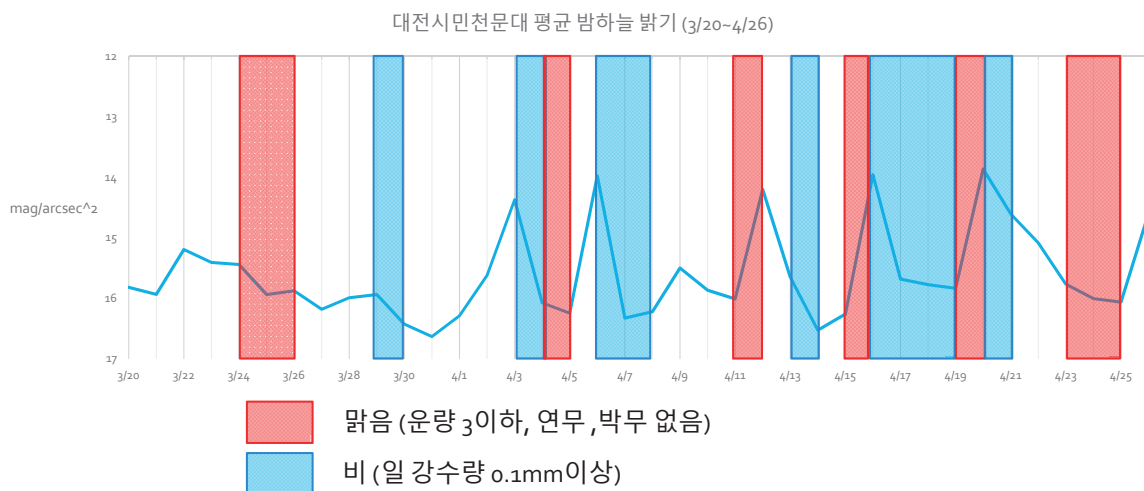
영양 반딧불이천문대 평균 밤하늘 밝기 (3/20 ~ 4/26)



관측데이터 - 달의 영향

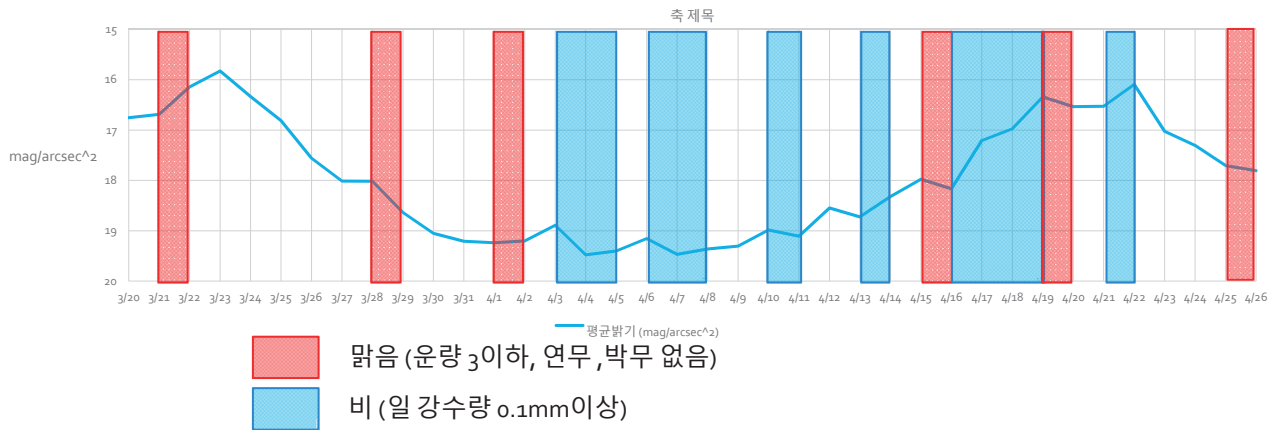


관측데이터 - 날씨의 영향



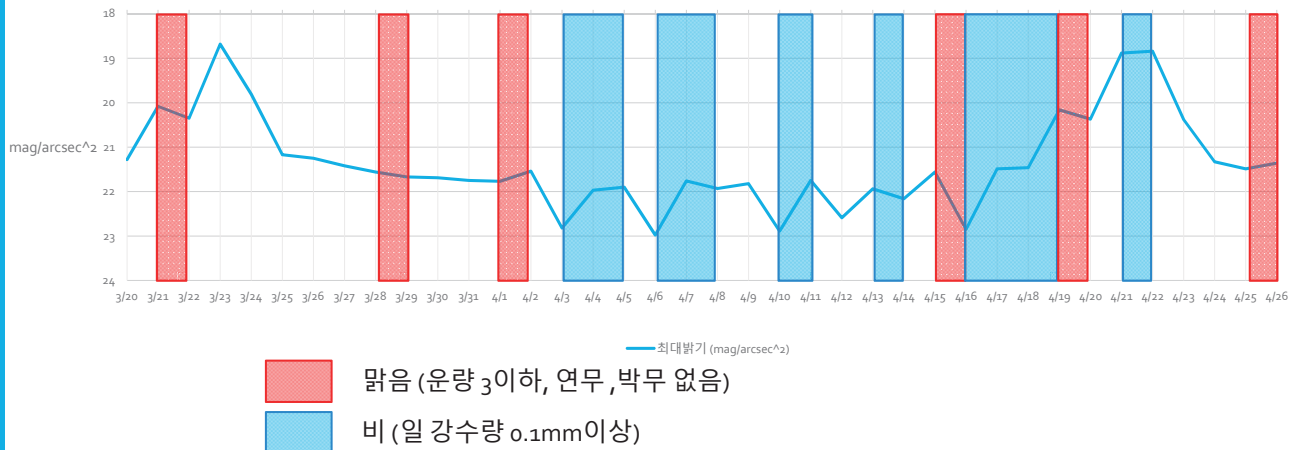
관측데이터 - 날씨의 영향

영양 반딧불이천문대 평균 밤하늘 밝기 (3/20 ~ 4/26)



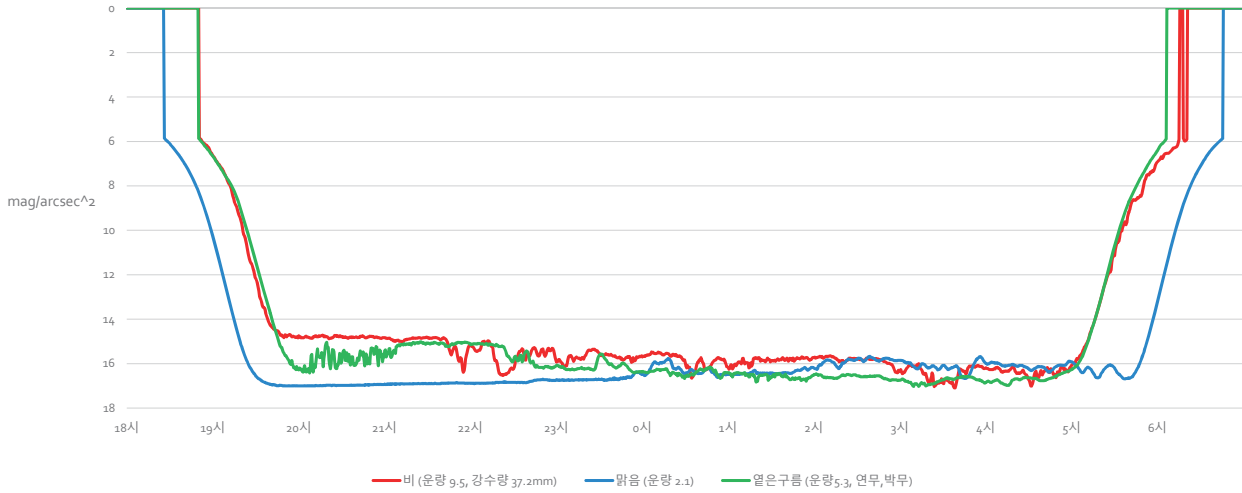
관측데이터 - 날씨의 영향

영양 반딧불이 천문대 밤하늘 밝기 최대값



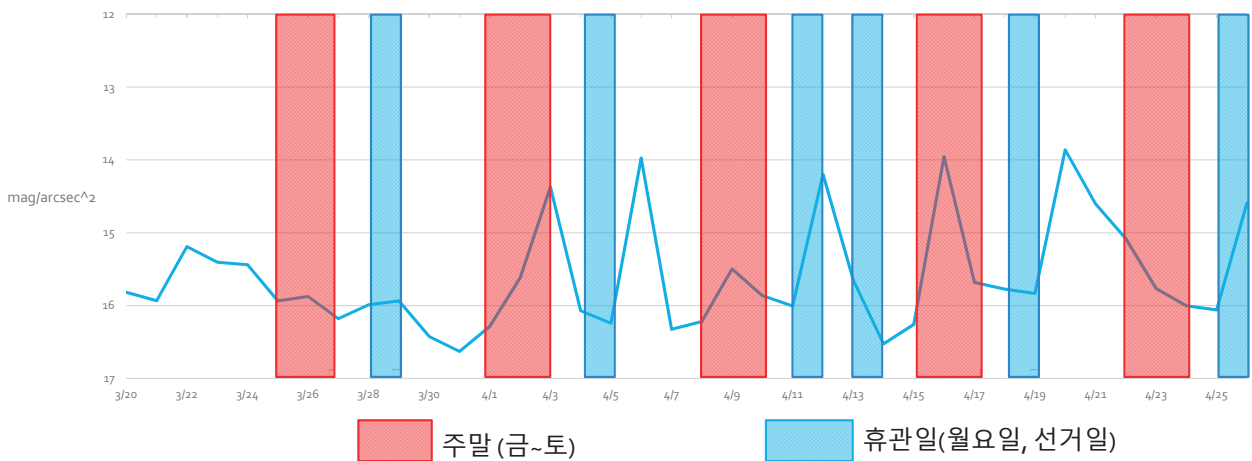
관측데이터 - 날씨의 영향

밤하늘 밝기 (맑음 3/24~3/25, 비 4/21~4/22, 흐림 4/22~4/23)



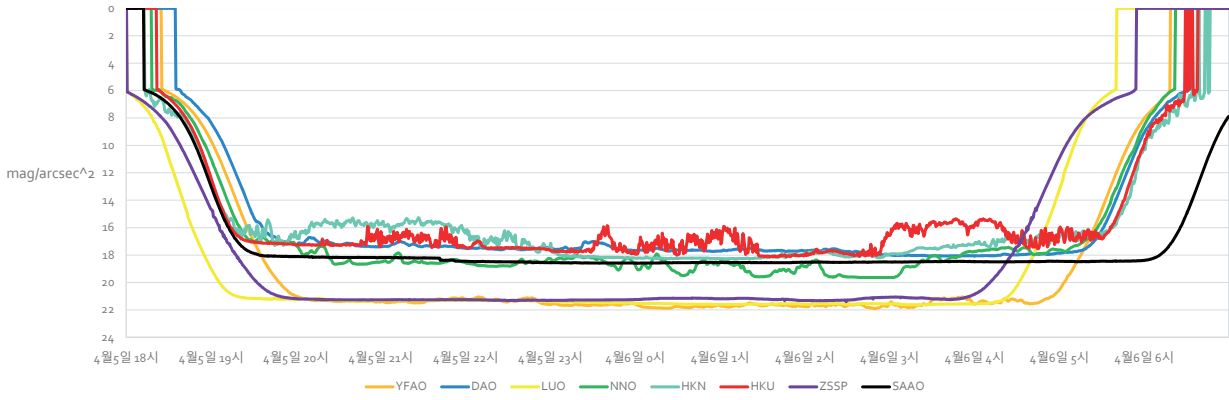
관측데이터 - 환경의 영향

대전시민천문대 평균 밤하늘 밝기 (3/20~4/26)



관측데이터 - 지역에 따른 밤하늘 밝기

지역별 요인



도시: DAO, NNO, HKU, HKN, SAAO

외곽: LUO, YFAO, ZSSP

Q & A



충북대학교 천문대의 SkyCCD 카메라 자료를 활용한 Sky Quality Meter(SQM) 측정결과 비교

¹충북대학교 천문우주학과, ²충북대학교 천문대

김동훈¹, 김용기^{1,2}, 윤요라^{1,2}



Outline

- I. Introduction
- II. Monitoring system
- III. Analysis
- IV. Conclusion
- V. Discussion



Introduction

빛 공해란 무엇인가?

정의

인공 조명의 부적절한 사용으로 인한 과도한 빛 또는 비추고자 하는 조명 영역 밖으로 누출되는 빛이 국민의 건강하고 쾌적한 생활을 방해하거나 환경에 피해를 주는 상태

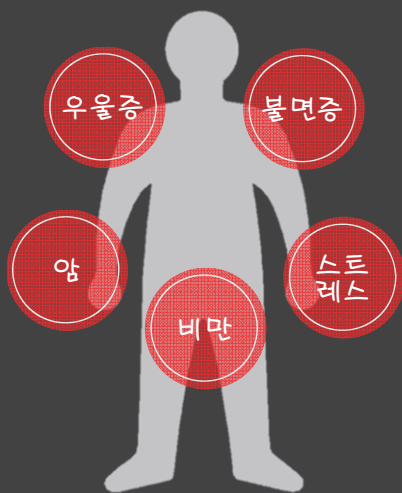
- 인공조명에 의한 빛공해 방지법 제2조 1항.

- 과도한 빛(over-illumination)은 필요이상의 빛을 사용하는 것.
- 조명 영역 밖으로 누출되는 빛(light trespass)은 원치 않은 빛이 개인적인 영역으로 들어가는 것.
- 인공 조명 : 가로등, 형광등, 보안등, 광고 조명, 장식조명 등.



Introduction

빛 공해의 문제점



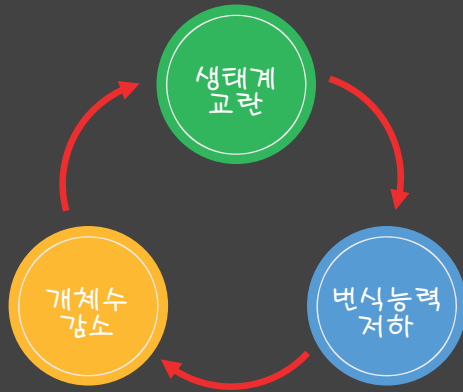
★ 인체에 미치는 영향

- 과도한 빛에 의한 눈의 순응 장애
- 강한 방전램프에 의한 수면 부족
- 서카디안 리듬(circadian rhythms) 교란
- 불면증, 비만, 당뇨, 우울증 및 조울증
- 멜라토닌 감소로 인한 암 발생 증가
- 스트레스 및 불안
- 성장 장애 및 시력 저하



Introduction

빛 공해의 문제점



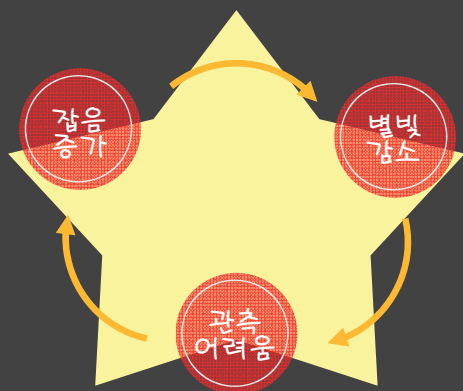
★ 생태계에 미치는 영향

- 번식 능력 저하로 인한 개체수 감소
- 포식자에게 쉽게 노출됨
- 야간시의 손상으로 인한 사망률 증가
- 동물성 플랑크톤 성장 방해 (녹조 현상)
- 야행성 곤충의 비행능력 감소
- 어선의 인공조명으로 인한 어류 번식 저하
- 밤에 이동하는 철새들의 방향 감각 저하
- 벼, 보리 등의 출수 지연



Introduction

빛 공해의 문제점



★ 천체관측에 미치는 영향

- 관측 가능한 별 개수 감소
- 천체 관측에 불필요한 잡음 증가
-
-



Introduction

The Global at Night - Sky Brightness Monitoring Network in Korea



(Kim, et al., 2015)



Introduction

충북대학교 천문대 Weather Monitoring System

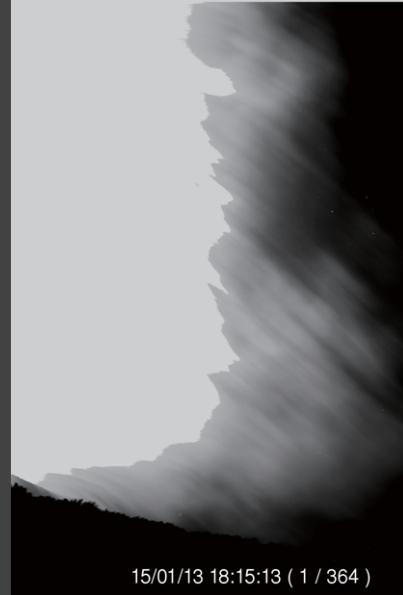
- 관측 정밀도를 향상 시키기 위해 2009년부터 기상 및 관측 상황을 모니터링.
- 온도, 습도, 기압, 풍향 및 풍속을 각각 측정 할 수 있는 5개의 센서.
- 구름량 측정을 위한 wide-field Sky CCD system (Sky CCD).
- The automatic weather monitoring system(AWS)은 기상 측정자료를 기록.
- FTP 프로토콜을 사용하여 서버로 자동 전송.
- 서버로 전송된 기상 측정자료는 <http://210.125.158.20/weather>에서 실시간으로 제공.

(Yoon, et al., 2012)



Introduction

Wide-field sky CCD image animation



Introduction

충북대학교 천문대 SQM-LE

- 2015년은 UN이 지정한 세계 빛의 해.
- 빛 공해에 대한 문제점을 인식하고, 밤하늘 밝기 측정을 위한 활동에 대한 관심 증가.
- Unihedron에서 밤하늘 밝기 측정 장비 Sky Quality Meter 제작 및 판매.
- 2015.1.27부터 충북대학교 천문대 진천관측소에 설치하여 측정 중.
- 관측된 정보는 서버로 자동 전송.
- 서버로 전송된 밝기 측정자료는 <http://128.199.94.197:8080/adminer.php>에서 제공.



Introduction

연구 목표

충북대학교 천문대는 2009년부터 천문대의 기상 상황 정보를 포함하고 있는 Weather Station 서비스를 제공하고 있는 바, 본 연구는 이 서비스의 자료와 SQM-LE의 자료를 이용하여 충북대학교 진천관측소의 밤하늘 밝기를 측정하고 그 결과에 대하여 논의 하고자 한다.

제공하는 SQM의 측정 자료 비교 통해 SQM의 정밀도에 대하여 논의 하고자 한다.



Monitoring system

충북대학교 천문대 wide-field Sky CCD system



★사양

- CCD : SBIG ST-8
- CCD chip : KAF-1603ME
- Resolution : 1,530 × 1,020
- Pixel size : 9 μ m
- Exposure time : 50s
- Lens : 8 mm Fisheye lens
- FoV : 59°.7 × 81°.5
- Direction : North-west sky

(Yoon, et al., 2012)



Monitoring system

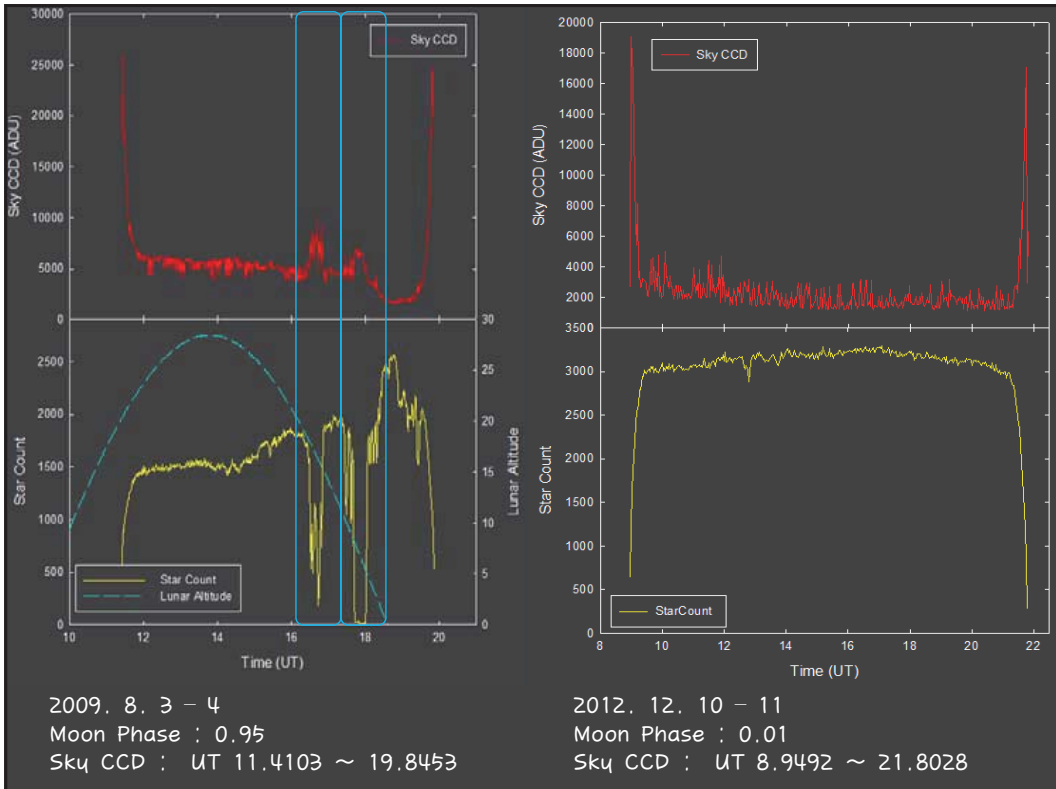
충북대학교 천문대 wide-field Sky CCD system



- 구름량 측정 시스템은 북극성 근처 밤하늘을 매번 50s 노출로 측정.
- TPG로 변환된 하늘 영상과 측정된 별 개수는 서버로 전송.
- 낮 동안 태양에 의한 카메라 손상을 방지 하기 위해 북서 방향 관측.

(Yoon, et al., 2012)

Fig. 4. Wide-field sky CCD system의 시야각.





Monitoring system

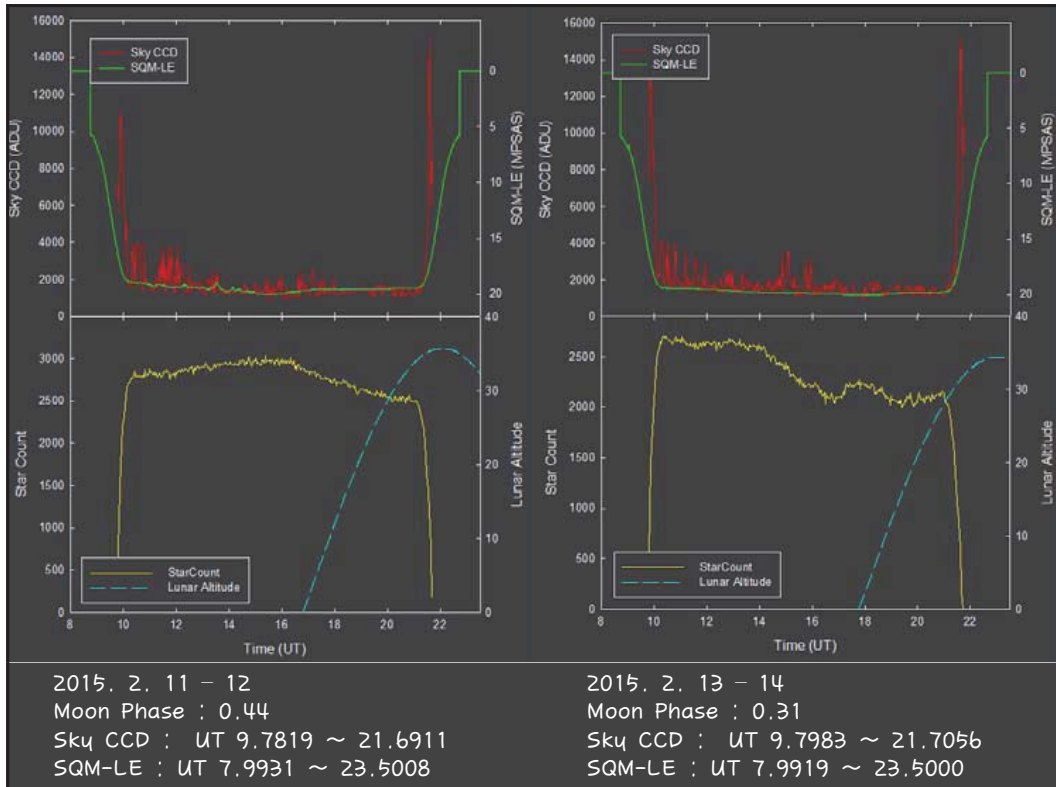
SQM-LE

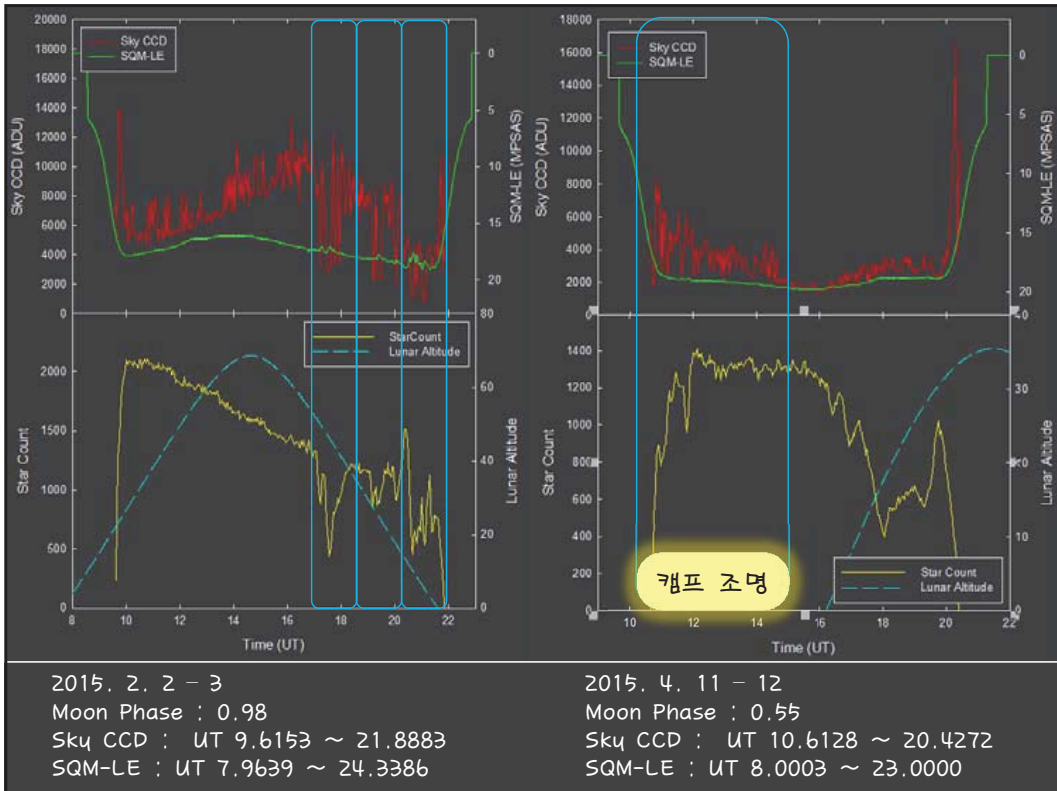
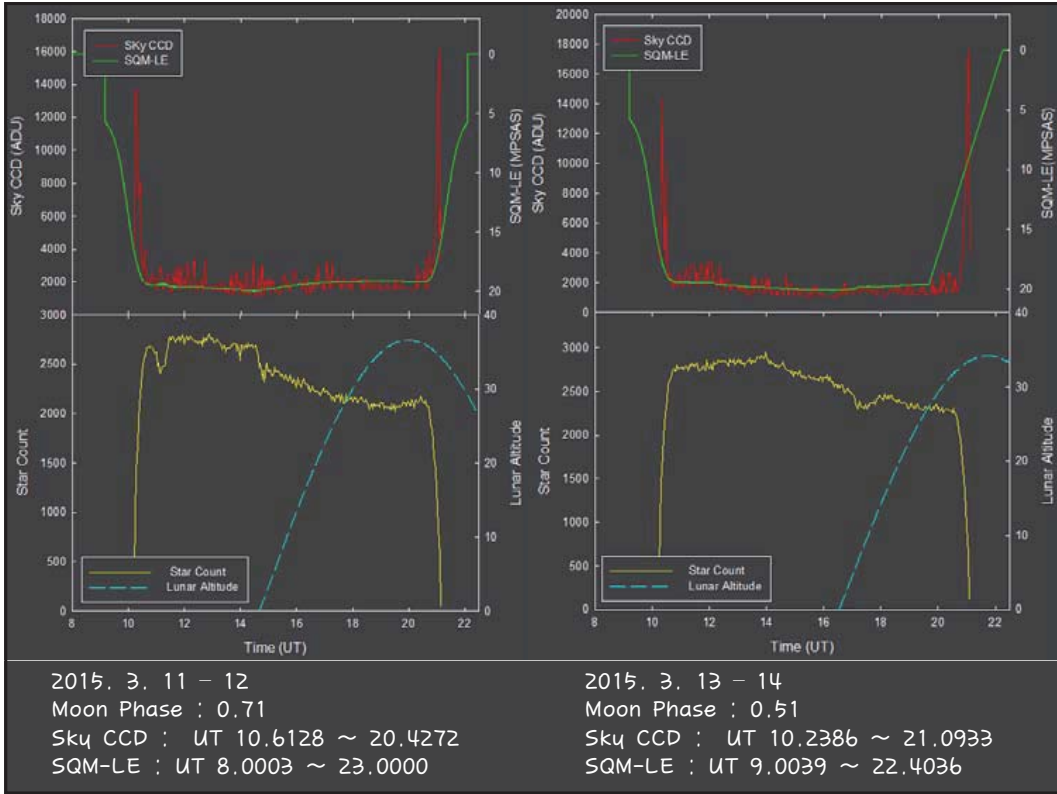
★ 사양



- Ethernet 연결 (LAN으로 연결가능)
- 광센서 : TAOS TSL237
Light-to-Frequency Converter
(320 ~ 700nm 파장대의 빛 감지)
- 근적외선 차단 필터 : Hoya CM-500
- 크기 : 3.6×2.6×1.1 in.
(9.1×6.6×2.8 cm)
- 5-6V DC adapter 사용
- mag/arcsec² 범위의 밤하늘 밝기 측정
- 0.1 mag/arcsec² 의 정밀도
- Direction : Up

<http://unihedron.com/>







Analysis

자료 분석

- SQM-LE 관측자료와 wide-field Sky CCD 관측자료를 비교.
- 관측값을 서로 비교하기 위해 단위 통일이 필요 ($ADU \rightarrow mag/arcsecond^2$).

$$m_{sky} = Q - 2.5 \log \left(\frac{P_{sky}/t}{A_{sky}} \right), \text{ (Duriscoe et al., 2007)}$$

- m_{sky} : Sky brightness in magnitudes per square arcseconds.
- Q : Instrumental zero point scaled to 1s exposure.
- P_{sky} : The median sky ADUs pixel⁻¹.
- A_{sky} : The area of 1 pixel in square arcseconds.



Analysis

자료 분석

- Q : Instrumental zero point scaled to 1s exposure.

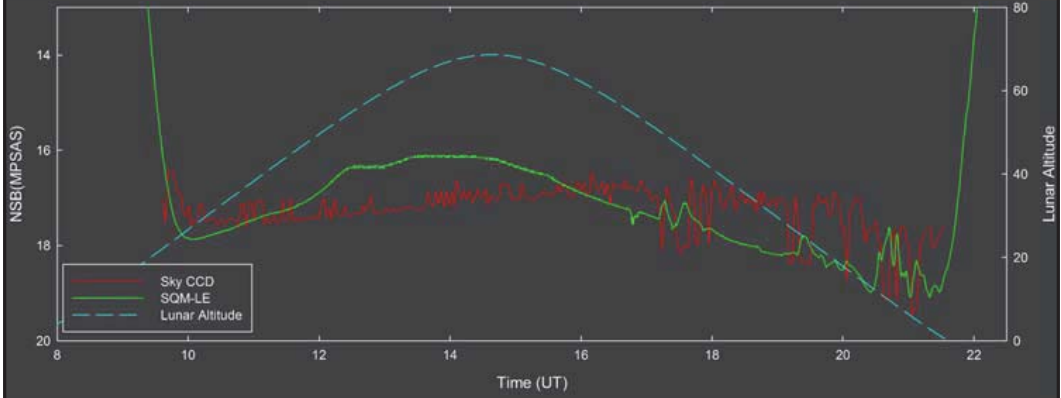
$$m = K - 2.5 \log(Flux)$$

- m : Standard stars of known magnitude.
- K : Photometric “zero point” (Q).
- Flux : Gain * Counts/Exptime.



Analysis

2015.02.02. (Full Moon, partially cloudy)

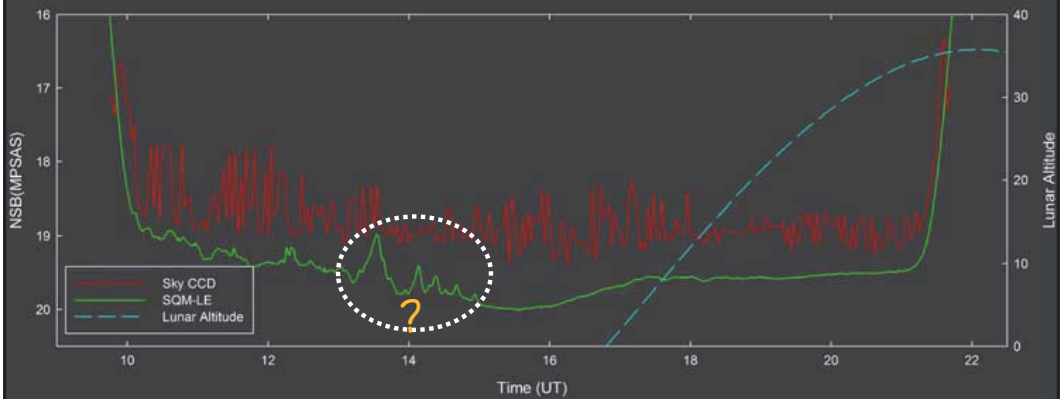


- Q : 11.14mag
- $\Delta NSB(NSB_{SQM-LE} - NSB_{SkyCCD})$: 평균 $0.05 \text{ mag/arcsecond}^2$



Analysis

2015.02.11. (Last quarter, Clear)

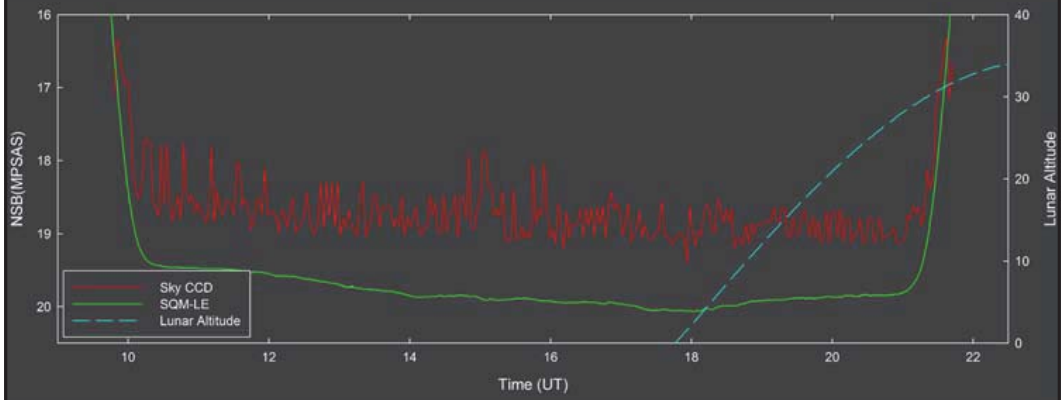


- Q : 10.97mag
- $\Delta NSB(NSB_{SQM-LE} - NSB_{SkyCCD})$: 평균 $0.75 \text{ mag/arcsecond}^2$



Analysis

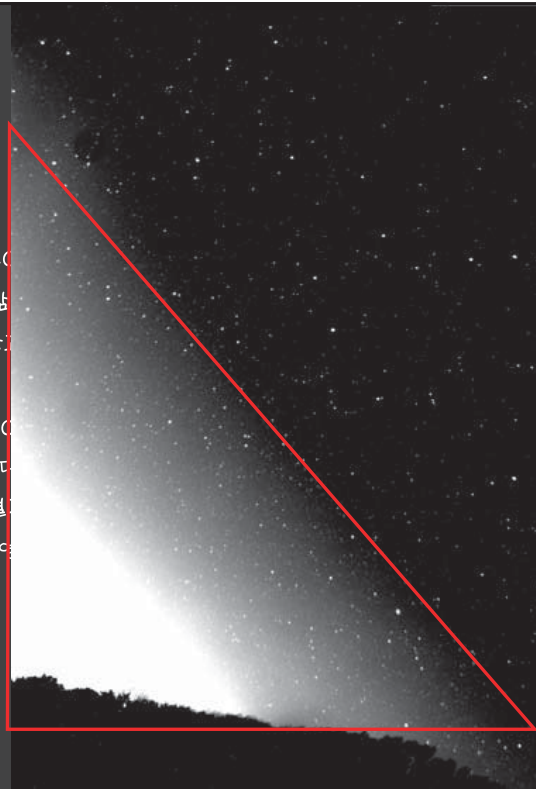
2015.02.13. (Last quarter, clear)



- Q : 10.67 mag
- $\Delta NSB (NSB_{SQM-LE} - NSB_{SkyCCD})$: 평균 1.05 mag/arcsecond²

Conclusion

- 구름량 측정을 위해 설치된 wide-field CCD를 통해 다양한 날의 충북대학교 천문대 밤하늘 관측 결과에 대해 분석하고, 구름량 측정에 영향을 주는 것을 확인.
- Full moon(2015.2.2~3)의 경우 Sky CCD와 SQM-LE의 관측 방향이 서로 다른 경우, 구름량 측정 결과에 영향을 미치는 것을 확인.
- 단위(MPSAS)를 통일 시켜 확인해 본 결과, Sky CCD가 관측하는 북서쪽 하늘에 밝은 구름이 많이 관측되는 것을 확인.





Discussion

- 현재 충북대학교 천문대에 설치된 SQM-LE가 때때로 기기 작동불능 문제로 밤 하늘 밝기 변화 모니터링 및 경밀도 분석에 어려움 발생.
- Sky CCD와 SQM-LE의 밤 하늘 밝기 결과의 차이를 통해 서로 다른 관측방향이 주는 영향이 클 것으로 생각되며, 이를 확인하기 위한 추가 연구 필요.
- Sky CCD와 SQM-LE 하우징에 설치된 유리와 필터에 반사되는 빛이 주는 영향에 대한 연구가 필요.
- 꾸준한 모니터링으로 충북대학교 천문대 주변에서 밤하늘 밝기에 영향을 주는 원인을 찾고 이를 해결하기 위한 방안을 모색할 필요가 있음.

- Y, Kim, J-H, Yoon, J, Park, A-C, Sul, "The Globe at Night in Korea-Sky Brightness Monitoring Network", KSSS (2015)
- D., M., Duriscoe, C., B., Luginbuhl & C., A., Moore. "Measuring Night-Sky Brightness with a Wide-Field CCD Camera", PASP, 192-213 (2007).
- J-N, Yoon, YS, Lee, C-H, Kim, Y, Kim, H-S, Yim, W, Han & JH, Jang, "statistical Analysis on Weather Conditions at Chungbuk National University Observatory in Jincheon, Korea", IASS, 29(4), 397-405 (2012).
- Mira AI User's Guide [Internet], cited 2012 Mar, available from: http://mirametrics.com/help/mira_al_8/
- Sky Quality Meter-LE [Internet], cited Mar, available from: <http://www.uninedron.com/projects/sqm-le/>



International Workshop on Night Sky Brightness Measurements

May 2~3, 2016 Chungbuk National University, Korea



Session III : SQM User Workshop

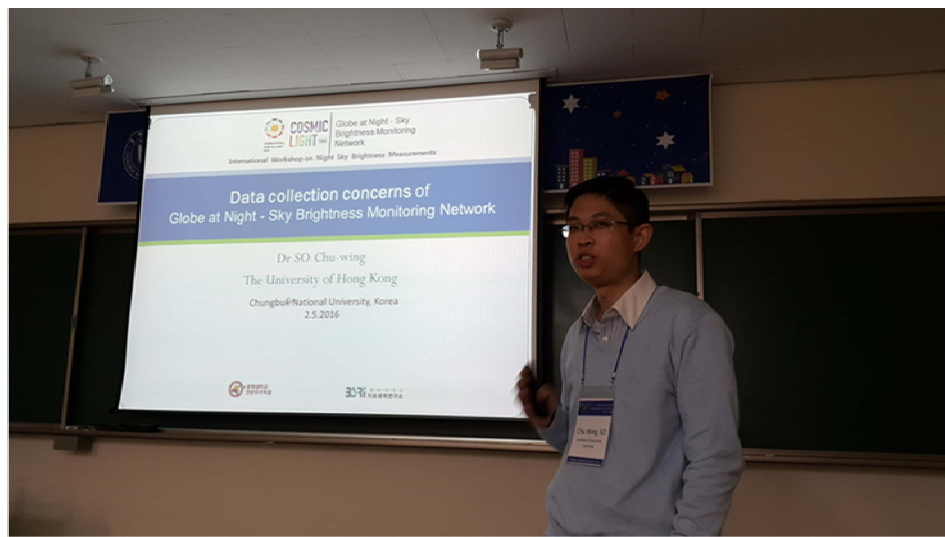
Chair: Jason PUN (University of Hong Kong, Hong Kong)

15:40 - 16:10 Chu Wing SO (University of Hong Kong, Hong Kong)

Data collection concerns of the Globe at Night - Sky Brightness Monitoring Network

16:10 - 18:00 participants of the Korean SQM users

free discussions about using SQM





Globe at Night - Sky
Brightness Monitoring
Network

International Workshop on Night Sky Brightness Measurements

Data collection concerns of Globe at Night - Sky Brightness Monitoring Network

Dr SO Chu-wing

The University of Hong Kong

Chungbuk National University, Korea

2.5.2016



Before data collection

2

International Workshop on Night Sky
Brightness Measurements
Korea, 2.5.2016



Globe at Night - Sky
Brightness Monitoring
Network



Selection of a good NSB monitoring location

- Outdoor, open space
- Without direct lighting nearby



Chungbuk National University Observatory

3

International Workshop on Night Sky Brightness Measurements Korea, 2.5.2016

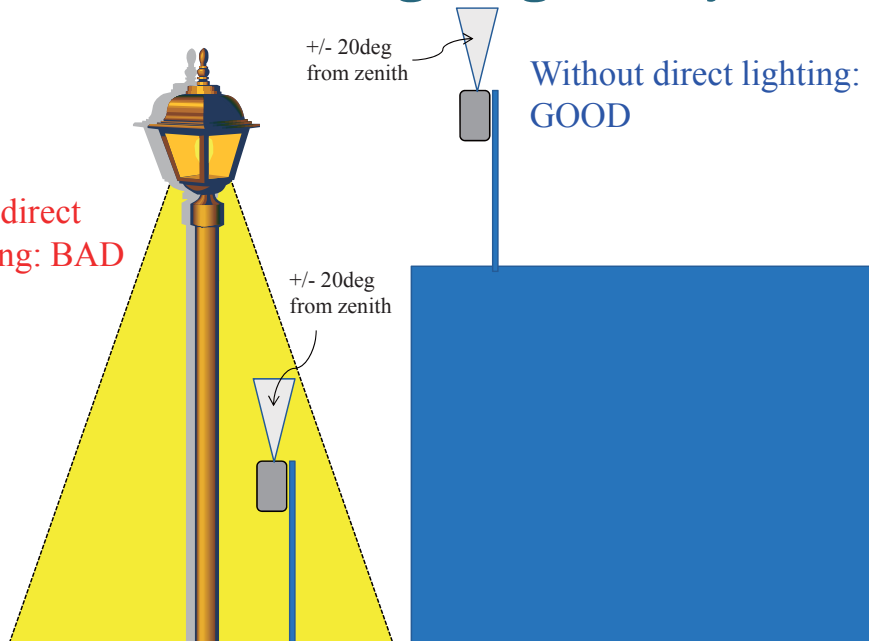


Globe at Night - Sky Brightness Monitoring Network



Without direct lighting nearby

With direct lighting: BAD



4

Selection of a good NSB monitoring location



- With mounting fixture(s)
- With power and network outlets (can be indoor or outdoor with protections)

5

International Workshop on Night Sky Brightness Measurements
Korea, 2.5.2016



Globe at Night - Sky Brightness Monitoring Network



Selection of a good NSB monitoring location – according to light pollution conditions

- To study how human factors contribute to NSB, select a station in urban:



This urban station was installed on the rooftop of a school located in a densely populated district with residential estates, shopping malls, and transportation hubs in Kowloon. At only nine storeys high, our detector was practically surrounded by taller buildings in all directions, with the closest one at about 70 m away extending up to about 30 degrees in zenith angle.

6

International Workshop on Night Sky Brightness Measurements
Korea, 2.5.2016



Globe at Night - Sky Brightness Monitoring Network



Selection of a good NSB monitoring location – according to light pollution conditions

- To study natural variations of NSB, select a station in rural:



This rural station was located on the rooftop of the marine science research center operated by HKU at one of the southeastern tips of the Hong Kong Island. The building lies on the shore of a marine reserve area with minimal amount of artificial lighting fixtures in the ambient environment to allow for ecological studies of the region. The main light source is a lighthouse (at a height 20 m above the observing module) located at about 200 m away.

7

International Workshop on Night Sky Brightness Measurements
Korea, 2.5.2016



Globe at Night - Sky Brightness Monitoring Network



Selection of a good NSB monitoring location – according to light pollution conditions

- Special land usage:



This station was installed within the confines of the Hong Kong International Airport. This busy airport operates 24 hours a day and most of the external lighting for air traffic remains turned on throughout the night. This station was installed on the rooftop of a facility building on the southwestern corner of the airport. The South runway and the airport passenger terminal are located about 500 m in North and 3 km in northeast. Both the HKO and the airport operator (Airport Authority Hong Kong) installed suites of advanced meteorological and air quality monitoring systems at different locations of the airport for air traffic operations and for environmental monitoring.

8

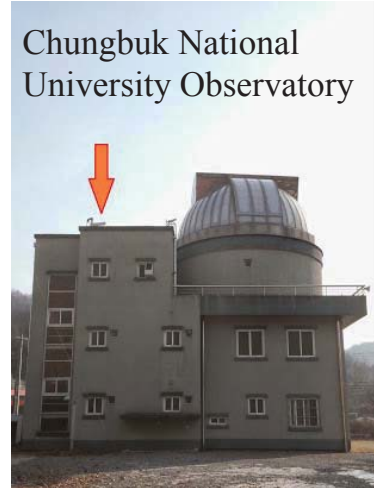
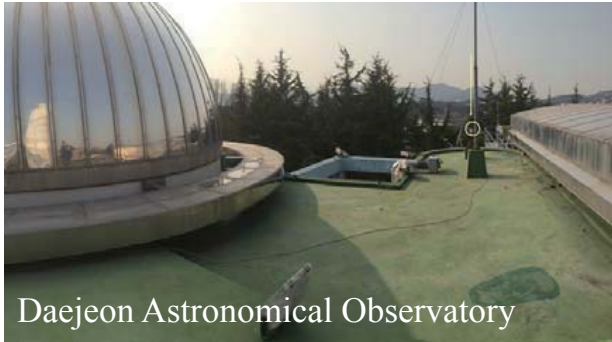
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Korea, 2.5.2016



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Examples of good NSB monitoring locations - rooftop



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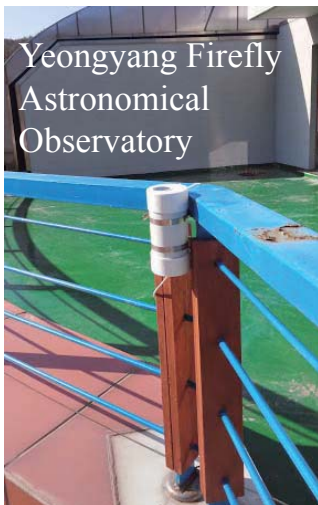
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Examples of good NSB monitoring locations - wall corner



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Materials needed

- A set of SQM-LE+H(+PoE)
 - SQM = Sky Quality Meter
 - L= Lensed: narrower angle of sensitivity
 - E = Ethernet: ethernet connectivity
 - H= Housing: protect SQM-LE
 - PoE = Power over Ethernet: transmit power and data using the same cable
- For networking:
 - A Cat5+ ethernet cable long enough to run from network point indoor to installation location outdoor
 - Internet connection
 - At least keep online during nighttime
 - A free network port
 - Default port: 80

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Network



Materials needed

- For powering
 - One power outlet (with power extension cord(s))
 - At least power-on during nighttime
 - Suggest to apply a timer to switch on the system before sunset and after sunrise
- For mounting
 - A metal pole or wooden pole or railing
 - A cable gland and/or electrical tape (prefer outdoor grade)
 - Several cable ties (prefer outdoor grade) and/or stainless steel hoses
 - Other tools
 - May require drilling works

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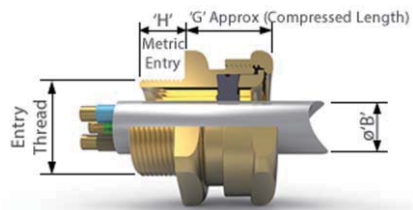
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cable glands



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steel hoses



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Operation of SQM-LE

- Housing:
 - Weatherproof
 - Made in PVC
 - Length ~ 20 cm
 - Weight ~ 650 g
- Power:
 - Powered by “Power-over-Ethernet (PoE)”: 48V DC 400mA to 5 V DC (SQM-LE)
 - Power consumption < 7 W
 - < 5.2kWh /month
- Data transfer:
 - < 5 MB / month
- Sensing (SQM-LE):
 - Remote sensing
 - No light or radiation emit
- Maintenance:
 - Minimal except troubleshooting on power or network sometime

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After data collection

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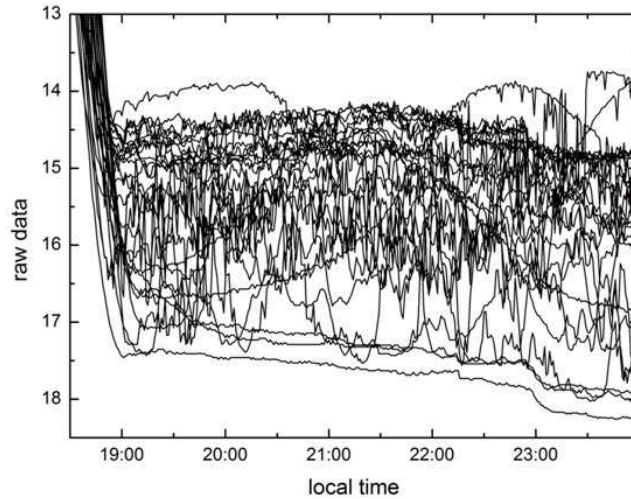


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What can you see (from raw data)?

Raw NSB covering Feb 2013 @ HKU



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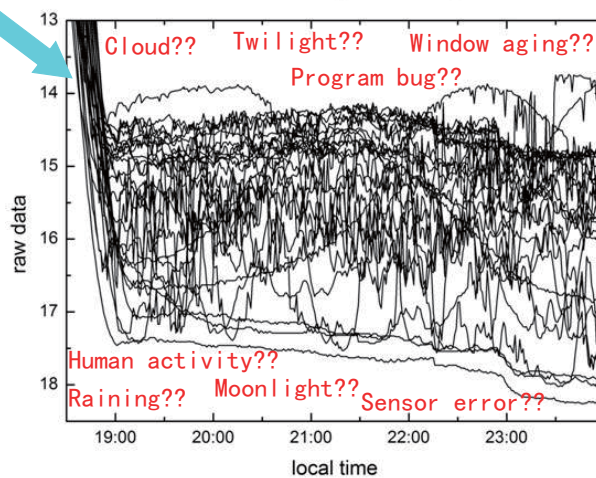


Examples of NSN raw data

- nightly NSB light curve taken over 28 days
- ~2.5 mag spread even at same site

- NSB data are taken every night
- They are taken over various human lighting, meteorological, and astronomical, etc conditions.

Raw NSB covering Feb 2013 @ HKU



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Factors affected raw NSB data

- Sunlight / twilight
- Unphysical NSB readings
 - e.g., ≤ 10 mag, ≥ 23 mag
- Aging / light attenuation of optics
 - SQM-LE's filter
 - Window of housing
- Non-routine lighting events
 - Stargazing events / private observations
 - Others: e.g., Earth Hour, holidays
- Natural phenomena
 - Moonlight
 - Scattered city light from clouds

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Sunlight / twilight

- Sunlight saturates the sensor of SQM-LE
- Twilight
 - Produced by sunlight scattering in the upper atmosphere.
 - The time between dawn and sunrise, or between sunset and dusk.
- Expect darker and darker readings after sunset / brighter and brighter readings before sunrise
- The sky is expected to be free from sunlight when the solar altitude is less than -18 degrees.
 - Astronomical dark

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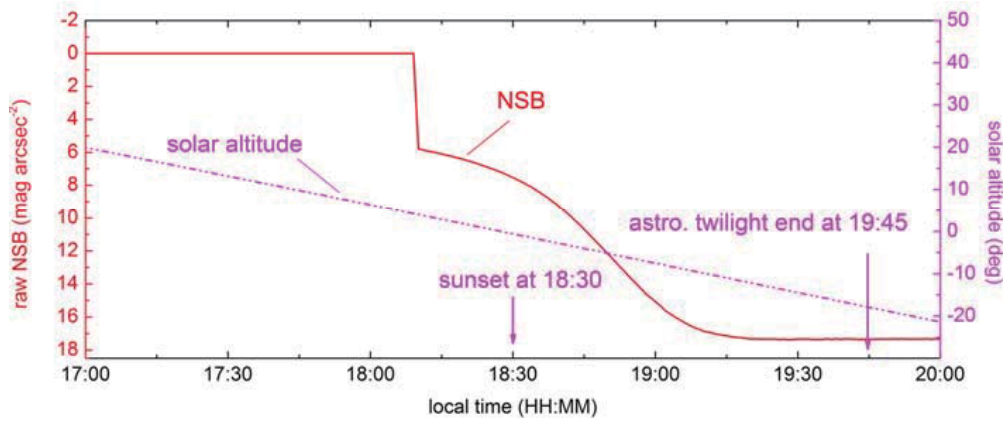


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Sunlight / twilight

- The example light curve below shows the contribution of sunlight.



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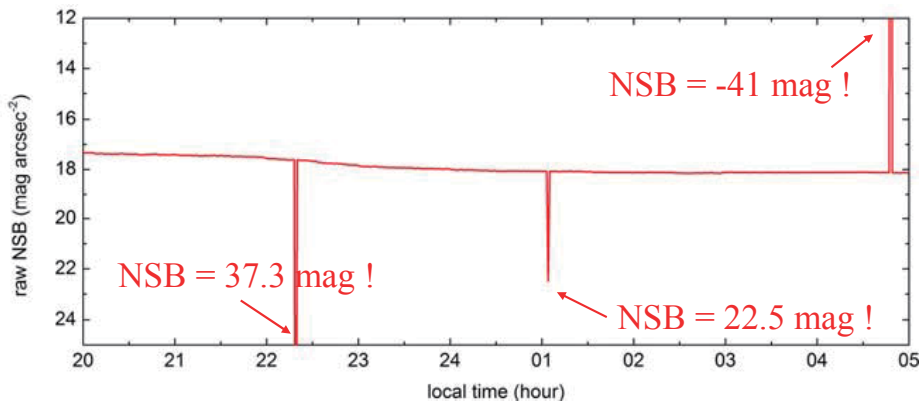
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Unphysical NSB readings

- The example light curve below records unphysical readings during a moonless evening.



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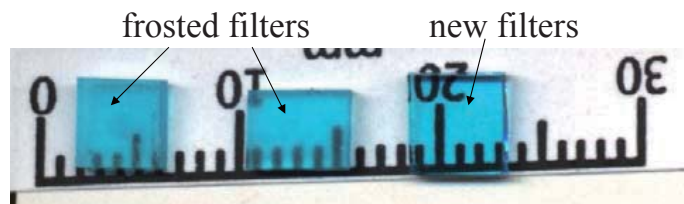
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Aging of optics – SQM-LE's filter

- In the past, the transparency of the filters covering the sensor of several units of SQM-LE were found to be reduced by up to 1 mag due to frosting.
 - tiny particulates in the air were carried to the filter glass by atmospheric moisture
 - anti-moisture coating was applied on newer models



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Light attenuation of glass window of Unihedron housing



- The light attenuation of the glass is
 - claimed to be around 0.11 mag by Unihedron
 - measured to be around 0.07 mag by HKU
- The long term aging effect of the window is not known yet
 - One of the error sources

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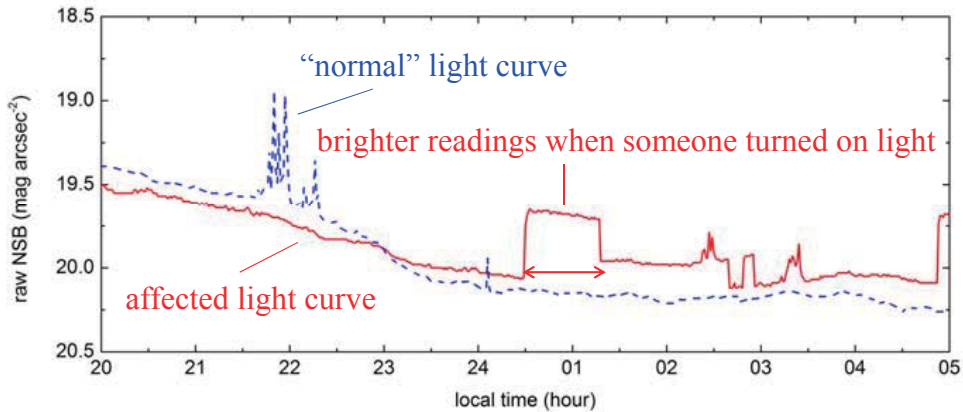
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Non-routine lighting events

- The example red light curve below was affected by a stargazing event in a rural location during a moonless evening.



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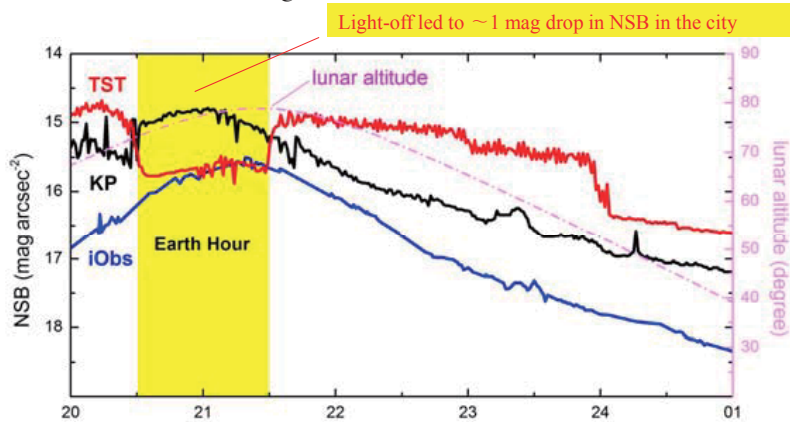


Globe at Night - Sky Brightness Monitoring Network



Non-routine lighting events

- The example light curves below describe the variations of NSB in different locations during the “Earth Hour” event* on 23 March 2013.



* Earth Hour is held annually by WWF which encourages individuals, communities, households and businesses to turn off their non-essential lights during 20:30-21:30, as a symbol for their commitment to the planet.

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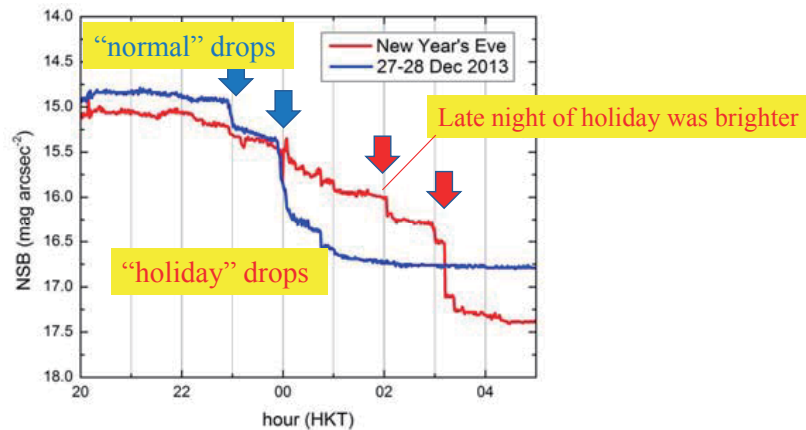


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Non-routine lighting events

- The example red light curve below describes the variation of NSB in a urban location during 2013-14 New Year's Eve .



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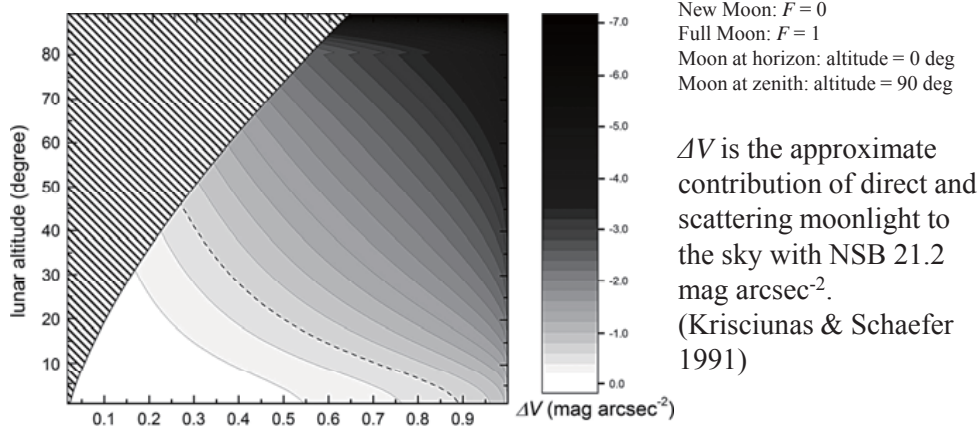


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Moonlight

- The intensity of moonlight depends on lunar phase (F) and altitude



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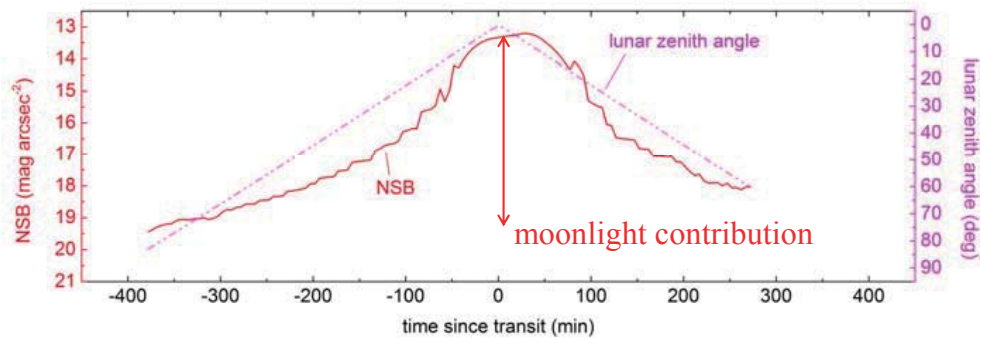


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Moonlight

- The example light curve below shows the contribution of moonlight (up to about 6 mag arcsec⁻²) in a rural location when the Moon is near full and close to the zenith and the sky is clear.



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Scattered city light from clouds

- Depends on the optical properties of clouds, the scattered city light from clouds would contribute significantly to the NSB observed.
- The cloud amount is strongly depended on:
 - observing location
 - observing time

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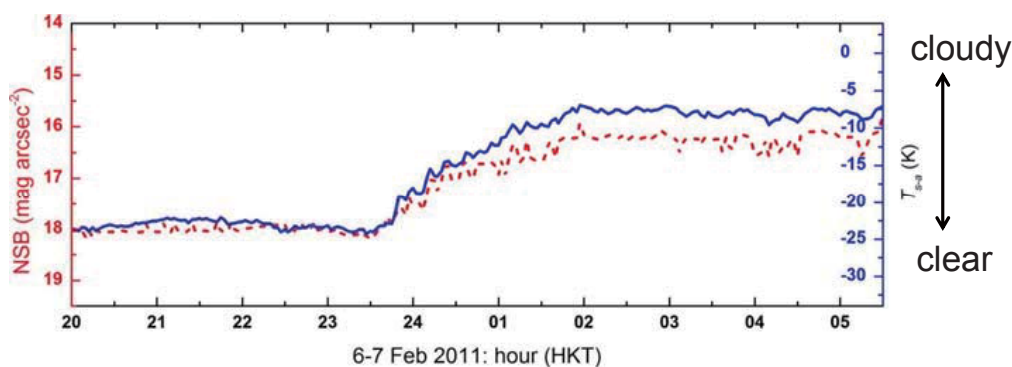
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Scattered city light from clouds

- The example light curve (dashed red: NSB) below shows the contribution of scattered light from clouds when clouds (solid blue) rolled in around mid-night.
 - Measured by the cloud sensor, T_{s-a} is the temperature difference between the ambient and the sky in IR



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Non-night-sky events

- The above factors that polluted the NSB light curves are known as “**non-night-sky**” events
 - Factors that do not truly reflect the **general** night sky (light pollution) conditions
- “Non-night-sky” events
 - Have to be removed before conducting data analysis
 - Human events:
 - Keep good record of their occurrences for each observing location
 - Natural phenomena:
 - Check their occurrences from astronomical almanac, weather data, etc
- Details will be discussed in “Non-night-sky events” session.

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For additional details...

- Project website: <http://nightsky.physics.hku.hk/>
- Publications:
 - **Contributions of artificial lighting sources on light pollution in Hong Kong measured through a night sky brightness monitoring network**
Authors: Chun Shing Jason Pun, Chu Wing So, Wai Yan Leung, Chung Fai Wong
Journal of Quantitative Spectroscopy and Radiative Transfer
May 2014, Volume 139, Pages 90-108, DOI: 10.1016/j.jqsrt.2013.12.014
<http://www.sciencedirect.com/science/article/pii/S0022407313004950>
 - **Night-sky brightness monitoring in Hong Kong - A city-wide light pollution assessment**
Authors: Pun, Chun-shing, Jason and So, Chu-wing
Environmental Monitoring and Assessment
April 2012, Volume 184, Issue 4, pp 2537-2557, DOI: 10.1007/s10661-011-2136-1
<http://www.springerlink.com/content/08814311727512q4/>

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International Workshop on Night Sky Brightness Measurements

May 2~3, 2016 Chungbuk National University, Korea



Date: 3 May 2016

Further Discussion for collaboration about Globe at Night-Monitoring Network





Globe at Night - Sky
Brightness Monitoring
Network

International Workshop on Night Sky Brightness Measurements

Education and outreach ideas on Light Pollution

Dr Jason Chun-Shing Pun & Dr Chu Wing So

The University of Hong Kong

Chungbuk National University, Korea

3.5.2016

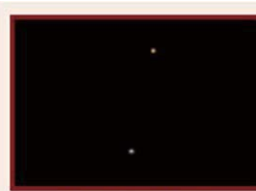


- Our first SQM survey: citizen science
- Light pollution: How to measure it?
- Knowledge Exchange Fund for Impact Project 2012
- Communicating with the public on light pollution:
 - Secondary school teachers / students
 - Environmental community
 - Media
 - Government
 - General public
- Looking ahead: Sustaining the efforts

Light pollution: What is it? Why do we care?

Measuring light pollution

- **Greensense (環保觸覺)**: Measure with a lux-meter, counting the number of signboards
- **Friends of Earth (地球之友)**: Invited the general public to report abusive lighting.
- **GLOBE @ night**: counting of number of stars visible at the Orion constellation



Magnitude 1 Chart

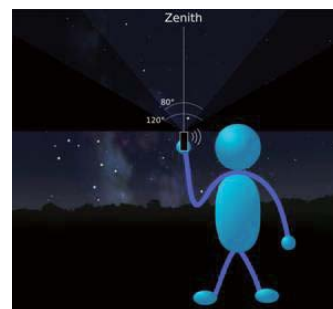


Magnitude 7 Chart

3

Measuring light pollution: night sky brightness

- **Sky Quality Meter**
 - portable meter for measuring sky brightness
 - precision $\sim \pm 10\%$
 - \sim US\$ 250
 - Results in units of **magnitude per square arcsecond ($\text{mag}/\text{arcsec}^2$)**
 - **A smaller reading means a brighter measurement**



4

香港特別行政區政府 HKSAR Government
環境及自然保育基金
Environment and Conservation Fund

香港大學 The University of Hong Kong
物理系 Department of Physics

香港光害調查

A Survey of **Light Pollution** in Hong Kong

First Phase (2008.3.15-2008.5.31)
Briefing Session

<http://nightsky.physics.hku.hk>

了解香港光害情況 Let's take Actions
to save our
Starry Night 為保育星空出一分力

Launched *A Survey of Light Pollution in Hong Kong*
with the support of the Environment and Conservation Fund of the
Hong Kong Government in Nov 2007

A Survey of Light Pollution in Hong Kong

- Assisting organizations:
 - Hong Kong Space Museum
 - Ho Koon Nature Education cum Astronomical Centre
 - **The Camping Association of Hong Kong, China, Ltd**
 - The Sky Observers' Association (Hong Kong)
- Invited secondary school students to participate (148 students from 28 schools)
- **Volunteers** reported measurements through web-based interface



6



<http://www.springerlink.com/content/08814311727512q4/>

Environ Monit Assess (2012) 184:2537–2557
 DOI 10.1007/s10661-011-2136-1

Night-sky brightness monitoring in Hong Kong

A city-wide light pollution assessment

Chun Shing Jason Pun · Chu Wing So

Received: 2 September 2010 / Accepted: 25 May 2011 / Published online: 29 June 2011
 © The Author(s) 2011. This article is published with open access at Springerlink.com

Abstract Results of the first comprehensive light pollution survey in Hong Kong are presented. The night-sky brightness was measured and monitored around the city using a portable light-sensing device called the Sky Quality Meter over a 15-month period beginning in March 2008. A total of 1,957 data sets were taken at 199 distinct locations, including urban and rural sites covering all 18 Administrative Districts of Hong Kong. The sur-

and/or environmental factors. Moreover, earlier night skies (at 9:30 p.m. local time) are generally brighter than later time (at 11:30 p.m.), which can be attributed to some public and commercial lightings being turned off later at night. On the other hand, no concrete relationship between the observed sky brightness and air pollutant concentrations could be established with the limited survey sampling. Results from this survey will

Measuring light pollution: night sky brightness

- Launched the *Hong Kong Night Sky Brightness Monitoring Network (NSN)* (香港夜空光度監測網絡) with the support of another ECF in June 2010



- Co-organizers: Hong Kong Space Museum, Hong Kong Observatory, Hokoon Nature Education cum Astronomy Centre

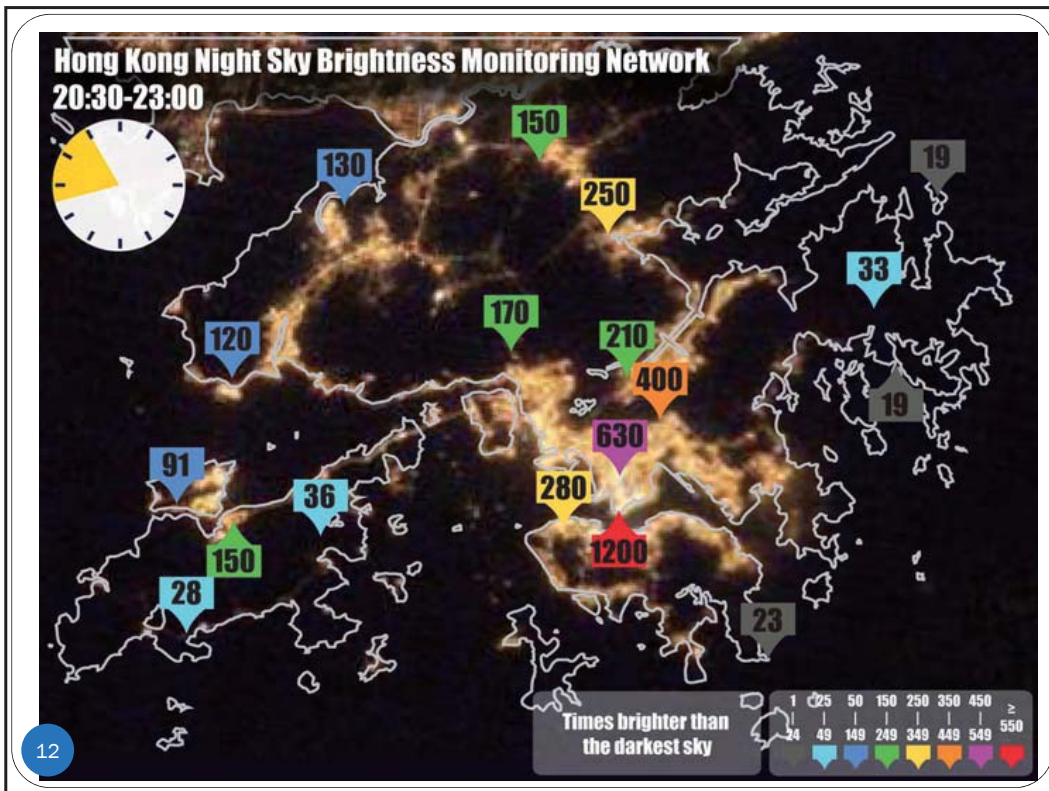
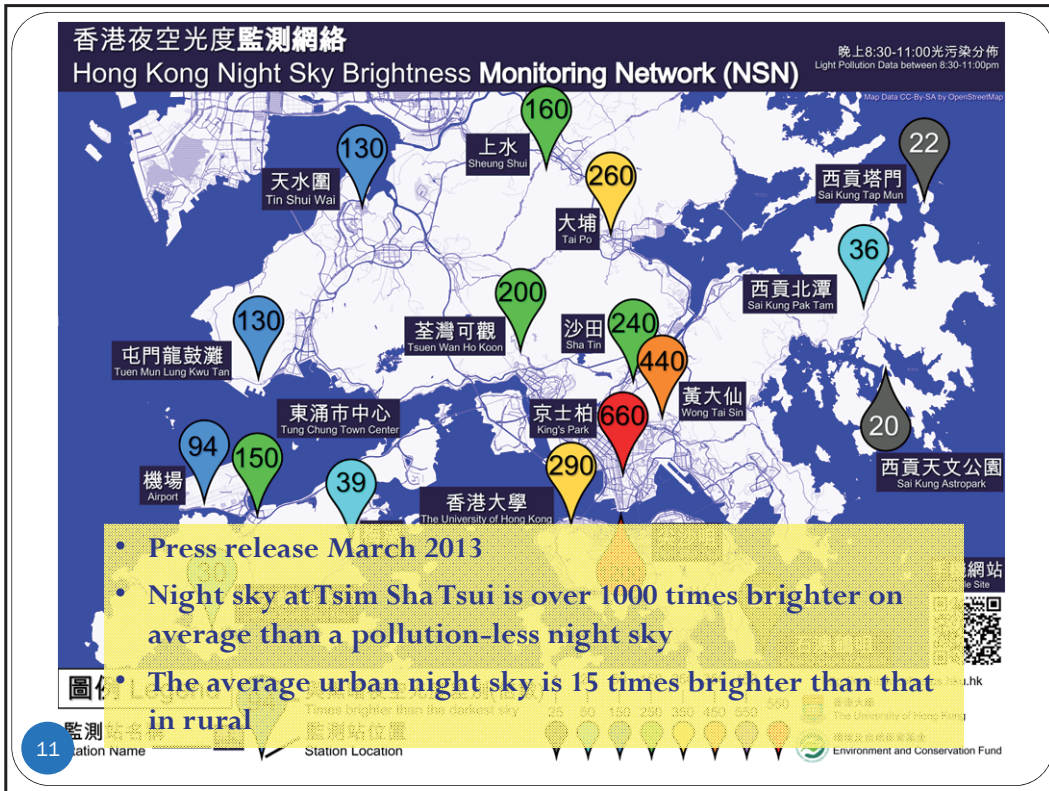
9

Measuring light pollution: night sky brightness



- Internet-ready version of the SQM installed in 18 locations for **automatic and continuous** measurements
- **Real-time** release of results over to the Internet.
- **Five million individual night sky measurements** collected.

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Community Light Pollution Reach-out Project (2012-13)

- **Objectives:**

- To promote the results from the Hong Kong light pollution study conducting in HKU to the public;
- To educate school students and the general public the science and environmental impacts of light pollution;
- To engage the community with light pollution research.

- **Two components:**

1. Secondary school program
2. High impact signature event (Science Roadshow)

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Community Light Pollution Reach-out: School program

- Organized workshops for 4 secondary schools
- Rundown of the workshop:
 - Lecture;
 - Measurement workshop;
 - Portable-dome observation
 - Exhibition
 - Student research



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Community Light Pollution Reach-out: Science Roadshow

- Co-organized with the Faculty of Science Outreach Team
- Science Roadshow at the Avenue of during Earth Hour 2013 organized by WWF
- Contents of the Roadshow:
 1. Real-time nights sky measurements;
 2. Demonstrations;
 3. Video presentations (<https://youtu.be/mc7ipCEXGsc>);
 4. Panel exhibitions



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Light Pollution Awareness Community Engagement Project (2013-14)

- Objective:
 - To engage the environmental community on the adverse impacts of light pollution
 - To engage secondary school students to conduct light pollution studies in their local surroundings
 - To promote measures to reduce the extent of light pollution in both ecologically sensitive rural areas and in urban communities
- Hong Kong government consultation paper: *Task Force on External Lighting Document for Engaging Stakeholders and the Public* (Deadline Nov 18) http://www.enb.gov.hk/external_lighting/

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Promotion Light Pollution Awareness: Research & Photography Competitions (2013-14)



Promotion Light Pollution Awareness: Research & Photography Competitions (2013-14)

想知明星百料? 即入 **星星廊** 起底!

港大辦研究攝影比賽 冀港人正視光污染

【on.cc 東網專訊】香港以璀璨夜

今年參加了一個科學專題比賽

Blinded by the light: Combating HK

Printed: 21 Aug 2014

It's official – Hong Kong has the world's light pollution in the world. All there are still its own to take (located at ground & Just) Don't suppose whether we should start to turn down the city lights.

Light pollution in Hong Kong really is the worst in the world – that was the finding from the first Sky Brightness Monitoring Network, a three-year study by a team of astronomers observing Hong Kong. The light pollution has the University of the Environmental Protection Department (EPA) who in the past, and NGOs are constantly equipped by reducing the outdoor lighting that we see in our night sky. Yet there is still no legislation on the subject of light pollution. Could it be the time for us to take the action?

One of the main problems with legislating light pollution is the difficulty to quantify it objectively. There is no official guidelines to indicate what is an acceptable amount of light and what is too much. The light pollution survey team at the University of the Environmental Protection Department (EPA) has been working on light pollution since 1997. The work means that there have been recorded data above the Science Museum in Tsing Yi since December 2009 and 7pm each night. The sky there is 1,200 times the sky elsewhere.

Remember back in 1970s when a standard problem in the national and international studies to measure light pollution, which is called light sky brightness, is any that has no artificial light. The work means that there have been recorded data above the Science Museum in Tsing Yi since December 2009 and 7pm each night. The sky there is 1,200 times the sky elsewhere.

Any combination of light will only a problem relative to the natural background. To see stars, we have to find the most dark areas. But in Sha Tin or 7 miles, we see as bright as the middle of a suburban square in Hong Kong (China), says Pan.

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Promotion Light Pollution Awareness: Research & Video Competitions (2015-16)

「星·夜·行」光污染實地考察
Light Pollution Field Trip

夜光
照地堂

<http://nightsky.physics.hku.hk/KE/201516/>

日期: 2015年11月28日 (星期六)
Date: 28 November 2015 (Saturday)

時間: 下午4時至晚上9時半
Time: 4:00pm - 9:30pm

地點: 香港大學明華綜合大樓T4講堂 (集合地點)、大埔郊自然護理區、西貢天文公園
Venue: HKU Meng Wah Complex Lecture Hall T4 (gathering), Tai Po Kau Nature Reserve, AstroPark

費用全免, 名額有限, 先到先得。
Free of charge, limited quota, first come, first served

截止報名日期: 2015年11月13日
Deadline: 13 November 2015

活動內容: 介紹光污染, 簡介「光污染研究比賽2015-16」及「光污染短片製作比賽2015-16」, 觀火蟲觀賞, 觀星, 對受光污染影響的地點考察
Contents: Introduction to light pollution, briefing of Light Pollution Research Competition 2015-16 and Light Pollution Video Competition 2015-16, firefly viewing, stargazing, visit to sites affected by light pollution

歡迎公眾參與 Welcome for public

報名及查詢詳情請瀏覽上述網頁。Please visit the above website for details.

Program rundown:

- Introduction talks on light pollution
- Briefing of competitions
- Field trip to experience first-hand impacts of light pollution:
 - Start from urban city center
 - Country park firefly viewing
 - Stargazing in astro-park

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Promotion Light Pollution Awareness: Research & Video Competitions (2015-16)



Youtube playlist
https://www.youtube.com/playlist?list=PLg43v2VBJ7WHV03t6S_oazqONXub4gi_I

Communicating with the public on light pollution

Hong Kong – Asia's World City



Religious worshipping – traditional Chinese style

A big challenge in a city deeply proud of her identity as the *bright* “Pearl of the Orient”

Hong Kong is a unique blend of diverse cultures and East-meets-West. It is a city that has grown from a small fishing village to a global financial hub. Though relatively small in size, the choice of things to see, do and experience is vast for good visitors. Visit museums, see colonial buildings alongside modern architecture, explore historical landmarks, Buddhist and Taoist temples hidden amid the contemporary skyscrapers, catch a show, shop and dine or have fun at a theme park. There are many ways to get around Hong Kong; it is internationally famous for its safe, affordable and reliable public transport system.

Communicating with the public on light pollution (some personal thoughts)

- **Secondary School teachers and students:**

- Open to new ideas (particularly for students)
- Teachers and students are extremely busy!
- *Independent Enquiry Study* of Liberal Studies curriculum
- Engagement of teachers essential

- **Challenges:**

- Engaging students and teachers for an extended duration, and for deeper impact projects
- Extending our “core outreach group” from astronomy teachers to liberal studies teachers

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Communicating with the public on light pollution (some personal thoughts)

- **Environmental community:**

- Enthusiasm and dedication
- Knowledge and experience with media
- Appreciative of scientific inputs
- Generate synergy

- **Challenges:**

- Striking balance between objective scientific positions and advocacy

*Press conference organized by
Friends of Earth in 2009 on
Lights-out campaign*



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Communicating with the public on light pollution (some personal thoughts)

• Stakeholders in the community:

- Delivered 1 to 1.5 hour lectures for professional bodies, e.g.
 - The Hong Kong Institute of Housing 香港房屋經理學會
 - The Hong Kong Institute of Surveyors 香港測量師學會,
- Continuing Professional Development (CPD) point-earning
- Practical concerns from professionals on the ground

• Challenges:

- Learn the roles of various professionals in the community
- Learn the “language” of the different communities

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Communicating with the public on light pollution (some personal thoughts)

• Media:

- Light pollution a new issue when we started
- 80 newspaper/webpage reports, 20 TV/radio appearances
- Usually sympathetic of our concerns and willing to listen
- Fast-thinking and efficient in learning new ideas and concepts



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Communicating with the public on light pollution (some personal thoughts)

• Challenges:

- Explaining quantitative and logically complex arguments
- It was a struggle to explain “*The night sky in Tsim Sha Tsui is 1000 times brighter than the dark standard.*”
- Unique to us: A difficult unit to understand! (mag/arcsec²)
- Schedule: newspaper reporters usually complete their articles after 6pm (prepare for phone calls)
- Needs to be very careful with all information released.

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Light pollution of Hong Kong Space Museum over the limit by 1200 times.

港光害嚴重 太空館超標1200倍

香港東方之珠以璀璨奪目吸引遊客，但繁華背後卻令香港成為世界上光污染最嚴重之地，其中尖沙咀的夜空光害最惡劣，超過國際標準1,200倍，遠為觀星屋的西貢天文公園亦超標20倍。

港府數月後會建議限制時關燈等規範光害建議，但有參與者透露，措施至今未獲共識。

■本報記者 何詩穎

香港大學物理學系自行研發「香港夜空光度監測網絡」，並由05年5月開始，在全港18個地方，收集逾500萬個夜空光度數據，結果發現本港晚上8時半至11時，市區夜空光度較國際標準亮100至逾1,000倍，令香港成為全球光污染最嚴重地方之一。

如120枝球場射燈 照上夜空

當中，以尖沙咀香港太空館夜空的污染最嚴重，超標1,200倍。香港大學物理學系博士、「香港夜空光度監測網絡」研究主任潘振聲指，超標1,200倍即如同7.2萬枝的燈，也即等如有逾120枝球場射燈，在同一時間射向天空，形容超標數字驚人。

九龍尖沙咀豪宅區亦超標660倍，排第2，黃大仙排第3，超標440倍（見表）。

研究團隊指，12個市區監測站平均夜空光度，較6個郊區監測站高出10倍，其中尖沙咀與西貢天文公園更相差33倍，證明人為室外燈光亦是光污染嚴重的元兇。

事實上，光污染過強亦顯得受，其中天水圍濕地公園超標130倍，遠觀星屋西貢天文公園亦超標20倍。

地球之友副總監劉社鋒指，調查反映本港光污染問題，已由市區蔓延至郊區，或會令昆蟲以夜為晝，影響其作息時間。

劉續說，本港的光污染問題，已由招牌、商戶燈光，演變成很多燈光射向天，光線射上天後，不會集中一點，而是擴散至更遠；港大亦表示，射向天上的燈光，無助於照明，建議政府規定部分地方，需在指定時間內關燈。

限時關燈措施 小組未有共識

港府前年8月成立戶外燈光專責小組，研究如何規管燈光裝置，環境局局長黃錦星昨表示，委員會正作最後檢討，數月後會有建議，大方向是由從自願性措施，加大力度推出更有規範性的做法，例如限制關燈，冀今年中能與社會討論。

但本身是戶外燈光專責小組成員的劉社鋒稱，委員會對限制關燈應否自願性實行或作規管，以及應何時關燈，一直未有共識，他冀望政府管制戶外燈光關燈時間，最好定於11時後關燈。

香港十大光污染地區

排名	地點	超出國際標準倍數
第1位	香港太空館	1,200
第2位	尖沙咀	660
第3位	黃大仙	440
第4位	大埔	260
第5位	沙田	240
第6位	荃灣可觀	200
第7位	上水	160
第8位	東涌市中心	150
第9位	屯門龍鼓灘、濕地公園	130
第10位	機場	94

資料來源：香港大學物理學系



太空館的夜空光度超標1200倍，相當於有逾120枝球場射燈，在同一時間射向天空。

Light pollution from Hong Kong Space Museum over the limit by 1000 times

太空館光污染超標千倍

新界亦重災 學者倡強制限時熄招牌

香港夜間燈火通明贏得「東方之珠」美譽，但換來的代價卻是全球光污染最嚴重地區之一。香港大學物理學系三年前在港進行夜空光度監測研究，發現本港市區的夜空光度比國際標準超出一百至一千倍，其中鄰近大批名店燈招牌的尖沙咀太空館更一度超標一千二百倍，相當於逾一千個六十五瓦特 (Watt) 的燈籠照射，即使晚間人煙罕至的天水圍濕地公園亦難逃光害，夜間光度超標逾百倍。負責研究的學者承認現行自願性措施無約東力，建議港府可訂立法途徑，強制高戶限時熄掉不必要的戶外燈光，以免造成浪費及滋擾。

是次研究環境保護署轄下環境及自然保育基金資助，二〇一〇年五月至今年三月期間在港設置十八個監測站，每晚自動收集夜空數據，再傳送過大数据分析，結果發現，尖沙咀太空館是全港光污染之冠，晚上八時半至十一時的夜空光度，比國際天文學聯合會的標準超出一千倍，其次是尖沙咀和黃大仙監測站，分別超標六百六十倍和四百四十倍。

光度如1000個燈籠

新界偏遠地區超標情況亦見嚴重，大埔、沙田和荃灣可觀的夜空光度均超標逾二百倍，西貢天文公園則是全港最黑暗的監測站，但亦超標廿倍。負責是次研究的項目主任潘振聲分析指，歐洲、荷蘭等城市市中心的夜空光度超標不多於一百倍，對本港光污染嚴重超標感到震撼和驚訝，「平時球場射燈先得六百watt，太空館光度，就好似一千個六十五watt燈籠一齊照射燈籠光，呢種光度確實嚇性，真係好難形容。」

他又指，十二個市區監測站平均夜空光度達十五點六等每平方角秒，遠高於其餘六個郊區監測站接近十倍，隨著公共設施和商業照明入夜後陸續關上，夜空光度亦逐步遞減，證明廣告招牌和裝飾燈光等人為戶外燈光才是光污染元兇。港大已設立網頁實時公布香港各地的光污染程度，供市民參考，稍後會將研究結果提交環保署。



港大在太空館獲得夜空光度超標千倍，是香港光污染之冠。

Light pollution at/from Wetland Park is severe and affect the local ecological environment

尖沙嘴超標1,200倍 濕地公園衰過歐洲城市

「香港之光」污染爆標亂生態

【本報訊】香港大學過去兩年半測量本港各區的光污染，發現濕地公園夜空光度超出國際標準130倍，污染程度超越歐洲大城市的市區。尖沙嘴光害最嚴重，晚上8時半至11時錄得的光度，較「無污染」夜空超出1,200倍。負責有關研究的港大物理學系助理教授潘雁聲表示，政府應考慮立法規管不同區域按時段關燈。

港大物理系三年前研發「香港夜空光度監測網絡」，在全港18個地方安裝監測站，收集了收集夜空光度數據。研究根據國際天文學聯合會制訂的黑暗天空觀摩標準，以沒有人為光污染的夜空光度為基準，發現本港市區尖沙嘴的光污染，比無光污染的程度「超標」逾千倍。

研究指出，尖沙嘴光害最嚴重，晚上8時半至11時錄得的光度，較「無污染」夜空超出1,200倍。廣告招牌和向天射的區光燈是該區光害的元凶。光污染直至下半夜（即凌晨四時）才轉得下跌。此外，住宅區大埔、黃大仙亦分別超出260和440倍，光害直至凌晨才大幅下跌。天水圍濕地公園「超標」130倍，最暗的西貢天文公園亦「超標」20倍。

潘雁聲和饒文都認為政府應立法規管燈光，立法在不同地區和時段限制燈光，規範室外燈光設計。環境局長黃錦星昨稱，已成立委員會研究光污染，希望未來數月可以收緊規管，例如要求商戶在某些時間關掉不必要的燈。

潘雁聲指濕地公園的光害較歐洲城市市區更甚，西班牙首都馬德里和意大利佛羅倫薩市區光污染僅「超標」100倍，而郊區一般「超標」幾倍。他直言情況令人憂慮：「郊區情況及映得最擔心，濕地公園係一個新發展區好地帶，但光污染情況非常嚴重，對當地生態環境好有影響」。他估計，天水圍和深圳一帶發展迅速，是西北郊區光污染嚴重的主因。

香港夜空光度超標數據

濕地公園
光污染嚴重，危害當地生態。

記者：潘怡林

香港大學

www.hku.edu.hk

Communicating with the public on light pollution (some personal thoughts)

- **Government:**

- First two projects on light pollution ever funded by Environmental Protection Department (EPD).
- Huge help from the co-organizers of the project: Hong Kong Space Museum and Hong Kong Observatory
- Installed our equipment within government properties
- Experience of working with officials really varied

- **Challenges:**

- Extending the core audience from EPD to other government agencies who had a stake in the issue

Communicating with the public on light pollution (some personal thoughts)

- **General Public:**

- Talks, talks, and more talks... : Space Museum, community weather network, private corporation
- Our webpage provides the interface to communicate educational materials and research results to the public.
- *Google analytic* provided a means to measure the effectiveness of the responses

- **Challenges:**

- Communicating with skeptical segments of the public
- Maintaining the momentum

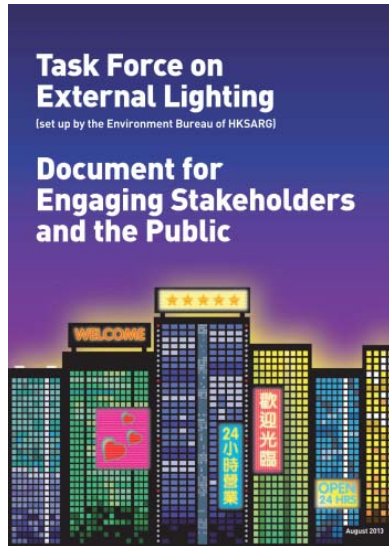
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How does Hong Kong government deal with light pollution?

- ~ 200 complains on light nuisance and energy wastage each year in 2009-2012
- The Environment Bureau issued “Guidelines on Industry Best Practices for External Lighting Installations” in 2012
 - Provide a reference for the trade and relevant parties in planning external lighting projects and their daily operation
 - Only voluntary “guidelines”, not mandatory
- The Bureau set up “Task Force on External Lighting” in 2011, conducted public consultation in 2013
 - Advise the government on the appropriate strategy and measures for tackling nuisance and energy wastage problems caused by external lighting
 - Problem of skyglow is irrelevant to the Task Force
 - Switch off lighting at either 23:00 or 00:00
 - The nightly profiles had shown that lighting are normally switched off at 23:00
- Light pollution condition will not be largely improved in short future

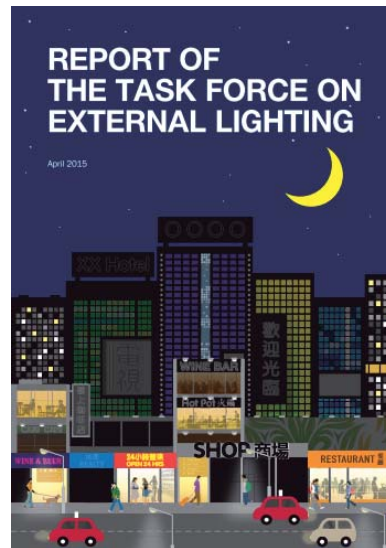
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How does Hong Kong government deal with light pollution?



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August 2013



April 2015

Guidelines on Industry Best Practices for External Lighting Installations (since January 2012)

Guidelines on Industry Best Practices for External Lighting Installations

The guidelines below suggest some best practices on external lighting installations that Government departments and the private sector should observe.

Introduction

1. External lighting in Hong Kong exist in many different forms and some typical examples include signs (either internally illuminated or externally illuminated), lighting for facades and features, lighting outside buildings (including those for shops), lighting for sports fields and playgrounds, external video structures (e.g. video walls, display panel).
2. The guidelines in this document aim to outline some general good practices on design, installation and operation of external lighting for the reference of lighting designers, contractors, owners and users with a view to minimising the adverse impacts arising from external lighting.

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How does Hong Kong government deal with light pollution?

Charter on External Lighting (since January 2016)

For those organisations pledging to sign up to the Charter and switch off lighting installations with decorative, promotional or advertising purposes which affect the outdoor environment during the following times:

Platinum Award: 11pm to 7am

Gold Award: midnight to 7am



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How does other countries with light pollution?

- Legislative controls against external lighting
 - Sydney, London, Frankfurt, Shanghai
 - assess light nuisance complaints on a case-by-case basis with regard to guidelines developed locally
 - New York City, Los Angeles
 - legislation relating to external lighting aims to prevent energy wastage of lighting installations
- Cities with no legislative controls
 - Tokyo, Singapore, Hong Kong

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source: "External Lighting in Hong Kong", Panel on Environmental Affairs, Legislative Council (2011)



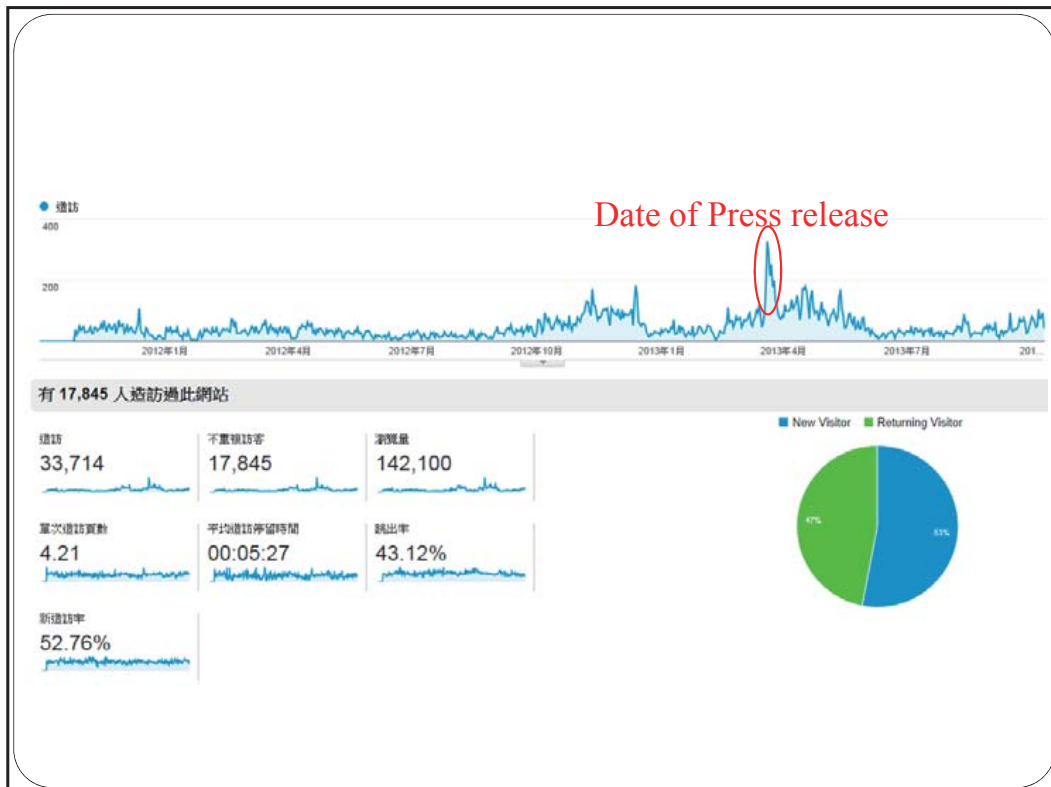
The Society of
Light and Lighting

Policy and status of light pollution management in Korea

JS Cha PhD, JW Lee MS, WS Lee MS, JW Jung MS, KM Lee BS, JS Han PhD and JH Gu MS
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Light pollution is emerging as one of the most rapidly increasing types of environmental degradation. Many localities have developed regulations to constrain the use of excessive light. Recently, the government of Korea has enacted and executed the 'Light Pollution Prevention Act' for the proper management of light pollution. This paper reviews the background and the main contents of the Act as well as the current status of light pollution in Korea. By this Act, a 'Light Pollution Prevention Committee' is established and the designation of environmental zones and the light emission standards for these zones are given. The contents of this study will be useful as a guideline for developing countries preparing light pollution management plans.



Hong Kong Night Sky Brightness Monitoring Network (NSN) : Mobile Site

- Smart phone or tablet users can get real-time night sky brightness

香港夜空光度監察網絡
Hong Kong Night Sky Brightness Monitoring Network (NSN)

昨晚資料 Last Night data

NSB	Station Name
17.9	香港大學天文台 HKU Observatory
17.1	香港天文台京士柏氣象站 King's Park Meteorological Station, Hong Kong Observatory
18	東涌空氣質素監測站 Tung Chung Air Quality Monitoring Station

香港太空館天文公園
Hong Kong Space Museum Astropark

夜空光度 (NSB): 20.2
等每平方角秒 mag/arcsec²

光度比最黑暗天空亮: 4
Times brighter than the darkest sky.

m

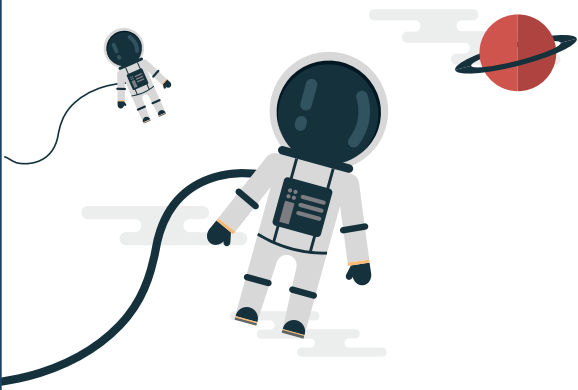
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Kim, Yonggi	Chungbuk National University, Korea
Kreiner, Jerzy M.	Pedagogical University of Cracow, Poland
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Lee, So-Jeong	Seoul Observatory, Korea
Lee, Yong-Sun	Daejeon Astronomical Observatory, Korea
Moon, Hong-Kyu	Korea Astronomy and Space Science Institute, Korea
Park, Dae-Young	Muju Firefly-star Astronomical Observatory, Korea
Park, Je-Hoon	Yeongyang Firefly Astronomical Observatory, Korea
Park, Ji-won	Chungbuk National University, Korea
Park, Ju-Yong	Hwacheon Choukyoungchol Astronomical Observatory, Korea
Park, Sung-Un	Jungmi Mountain Astronomical Observatory, Korea
Pun, Jason	University of Hong Kong, Hong Kong
Shin, Jeong-min	Daejeon Astronomical Observatory, Korea
So, Chu Wing	University of Hong Kong, Hong Kong
Son, Hyung-Kwan	Namwon Aircraft & Space Observatory, Korea
Suh, Kyung-Won	Chungbuk National University, Korea
Yoon, Joh-Na	Chungbuk National University, Korea
You, Ju-Sang	Hwacheon Choukyoungchol Astronomical Observatory, Korea

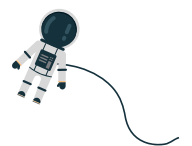


Organizing Committee:

- Chun Hwey Kim (CBNU, Korea)
- Yonggi Kim (Chair, CBNU, Korea)
- Jason Pun (HKU, Hong Kong)
- Jerzy Kreiner (PUC, Poland)



International Workshop on Night Sky Brightness Measurements



This workshop has been organized by the Institute for Basic Science Research, Chungbuk National University, and conducted by the department of astronomy and space science and the university observatory, Chungbuk National University