Globe at Night

Sky Brightness

Monitoring Network
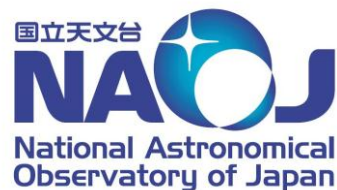
User Workshop, Jan 7-9, 2015

&

Post Workshop Meeting - Jan 10-11, 2015

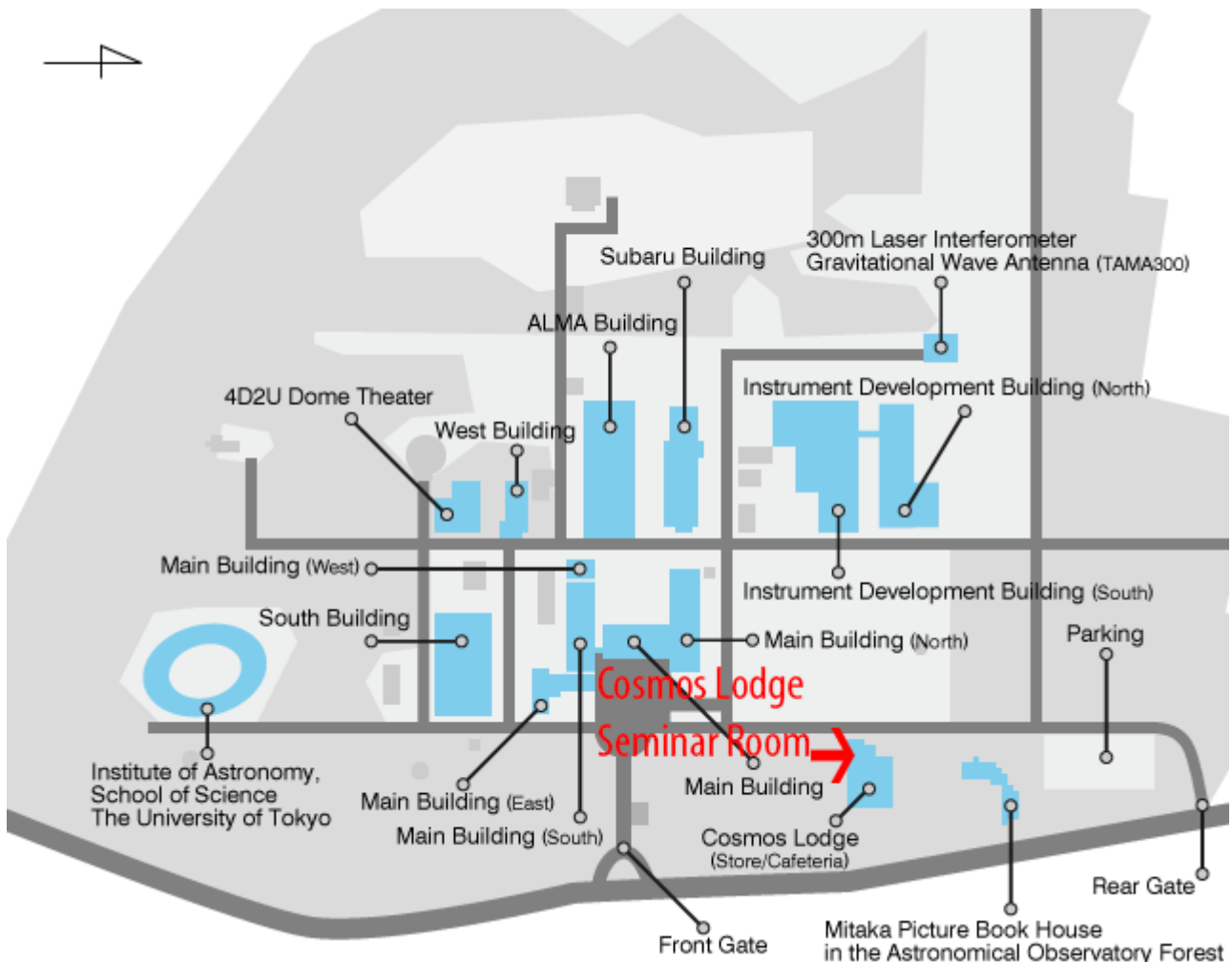National Astronomical Observatory of Japan

Tokyo, Japan

Date: Jan 7-9, 2015

Venue: Cosmos Lodge Seminar Room, National Astronomical Observatory of Japan, Mitaka, Tokyo, Japan

Target Participants:

- Users who already own the SQM-LE
- Invited person that would join the network

Transportation to NAOJ:

http://www.nao.ac.jp/en/access/mitaka/access.html

Online streaming:

- Jan 7, 2015 - https://global.gotomeeting.com/join/118764661
- Jan 8, 2015 - https://global.gotomeeting.com/join/390234437
- Please check the "Attendee Quick Reference Guide" on this page for the setup
  http://joingotomeeting.com/fec/?locale=en_US&set=true

Program

Please bring a laptop computer to the workshop

Jan 7, 2015 (Wed)

09:00 - 09:30	Registration	Cosmos Lodge Seminar Room
09:30 - 10:00	Welcoming, participant's self-introduction (including online participants)	
10:00 - 10:30	Talk: International Year of Light (Sze-leung Cheung, IAU Internatinoal Outreach Coordinator)	
10:30 - 10:45	Coffee Break	
10:45 - 12:00	Project Background: Case study and prototype in Hong Kong (Dr Jason Pun and Dr Chu Wing So, Mr Ryan Leung, The University of Hong Kong)	
12:00 - 13:00	Lunch	
13:30 - 16:00	SQM-LE workshop (Installation, Hardware configuration, calibration, Network setup)	
16:00 - 16:15	Coffee Break	
16:15 - 17:30	Participant's presentation and sharing, discussions - sharing by Prof Albert Kong, National Tsing Hua University, Taiwan - sharing by Prof Younggi Kim, Chungbuk National University, Korea	
18:00 - 21:00	Workshop Dinner	[Kashiwaya Soba, Mitaka](#)

Jan 8, 2015 (Thu)

09:00 - 09:30	Other possibilities: Using digital camera to measure light pollution (Fumiki Onoma, Yamada Junya, Shibayama Mayuko, Hoshizora Kodan - Japan)	Cosmos Lodge Seminar Room
09:30 - 10:30	Data Analysis session	
10:30 - 10:45	Coffee Break	
10:45 - 12:00	Educational activities for light pollution	
12:00 - 13:00	Lunch	

13:30 - 16:30	NAOJ Tour - Advanced Technology Center, Observatory History Museum, Exhibition Room, Solar Flare Telescope, 4D2U demostrations	
18:00 - 20:30	Public Lecture (English + Japanese bilingual) and Public Stargazing	Big seminar room

Jan 9, 2015 (Fri)

12:00 - 15:00	Astronomy Education in the Planetariums	Konica Minolta Planetarium @ Sunshine City, Ikebukuro
19:00 - 20:30	Public Stargazing	NAOJ Public Observatory

Language: English

Charges:

- Free of charge for the workshop
- 4500 JPY for the workshop dinner (grant holders will be covered)
- Planetarium show on Jan 9 - Free of charge

Post Workshop Meeting - Jan 10-11, 2015

A joint workshop meeting with the local Japanese secondary school students doing the light pollution measurements.

Venue:

Nobeyama Radio Observatory (http://www.nro.nao.ac.jp/en/),
Hamura Natural Village (http://hamura-kyukason.jp/)

Program

Jan 10, 2015 (Sat)

9:00 - 12:00	Bus departure for Nobeyama	
12:00 - 13:30	Lunch	

14:00 - 16:00	Visit Nobeyama Radio Observatory Talk and guided tour by NRO Director	Nobeyama Radio Observatory
16:00 - 17:00	Settle Down at Accommodation (training center of NRO)	
17:00 - 17:30	Depart for Kiyosato	
17:30 - 18:00	Meeting and sharing with secondary school students who run the light pollution measurements	Hamura natural relaxation village
18:00 - 19:30	Dinner	
19:30 - 21:00	Stargazing with secondary school students	
21:00 -	Return to accommodation	

Jan 11, 2015 (Sun)

9:00 - 12:00	Bus departure for Shinjuku	
	Dismiss at Mitaka or Shinjuku	

Participants are suggested to take the return flight on or after Jan 11 3pm.

Charge: 4500 JPY for lunch, dinner and accommodation (grant holders will be covered); transportation is complimentary

Accommodation: Arranged by LOC. Japanese style shared apartment.

- Nobeyama Radio Observatory

NAOJ Nobeyama is a project of the National Astronomical Observatory of Japan (NAOJ), an institute of the National Institute of Natural Sciences (NINS). NAOJ Nobeyama consists of two sub-divisions, the Nobeyama Radio Observatory (NRO), which specializes in observations of the outer space, and the Nobeyama Solar Radio Observatory (NSRO) whose main objective is to investigate the radio signal emitted by the sun. Nobeyama operates powerful, advanced radio telescopes such as the 45m radio telescope, the Atacama Submillimeter Telescope Experiment (ASTE) located in Chile, the Nobeyama Radioheliograph, and the Nobeyama Radio Polarimeter. Scientists and students from around the world visit Nobeyama for high quality astronomical research and state-of-the-art instrumental development.

- Yatsugatakechushinkogen Quasi-National Park

Yatsugatakechushinkogen Quasi-National Park is a mountain plateau that extends 50 km from Utsukushigahara Nagano Prefecture in the north through to Kiragamine, Tateshina, Kitayatsugatake to Yatsugatakenanroku in the south with Kiyosato and Nobeyama Plateau located in the southern part. Akadake, the highest peak in Yatsugatake straddles the border between Yamanashi and Nagano Prefectures and reaches an elevation of 2,899m (9,511ft). The expansive area at the foot of the peak forms a plateau resort area that is frequented by many guests and also supports a prosperous agricultural sector for raising vegetables and running dairy operations. Kiyosato Plateau offers a beautiful natural setting which can be enjoys in any season as well as views of Mt. Yatsugatake, Mt. Fuji, the Southern Alps, Chichibu mountain range, and other vistas in the national park.

- Hoshizora-kodan

Hoshizora Kodan is a nonprofit and voluntary group for co-existence of starry sky and city lights. It was established in 2007 and consists of over a hundred members. Main activities are stargazing parties under the city lights and continual surveillance of night sky in Japan from 2008. For more information please visit the website (http://www.kodan.jp/).

"Night Sky Analysis Workshop using Digital Camera" will be held for the purpose of propagating the knowledge about light-pollution and technique about measuring the night-sky brightness using digital still camera.

Participants

Name	Country	Institution
Jayanta Acharya	Nepal	Nepal Sanskrit University
Hidehiko Agata	Japan	National Astronomical Observatory of Japan
Makiko Aoki	Japan	National Astronomical Observatory of Japan
Sze-leung Cheung	Japan / Hong Kong	IAU Office for Astronomy Outreach
Bayarkhuu Chinzorig	Mongolia	National University of Mongolia
Thomas K.T. FOK	Hong Kong	Ho Koon Nature Education cum Astronomical Centre
Tokiko Fujita	Japan	National Astronomical Observatory of Japan
ONOMA Fumiki	Japan	Hoshizora Kodan
Kenneith Ho-keung Hui	Hong Kong	Ho Koon Nature Education cum Astronomical Centre
Naomi Ishikawa	Japan	National Astronomical Observatory of Japan
Shoichi Ito	Japan	National Astronomical Observatory of Japan
Yamada Junya	Japan	University of Miyazaki
Yonggi Kim	South Korea	Dept. of Astronomy and Space Science, Chungbuk National University
Hiroko Komiyama	Japan	National Astronomical Observatory of Japan
Albert Kong	Taiwan	Institute of Astronomy National Tsing Hua University
Ryan Leung	Hong Kong	The University of Hong Kong
Shibayama Mayuko	Japan	Hoshizora Kodan
Seiichiro Naito	Japan	National Astronomical Observatory of Japan
Sayumi Noguchi	Japan	National Astronomical Observatory of Japan
Yumiko Oasa	Japan	Saitama Univ.
Mitsuru Okura	Japan	Nagano City Museum
Jehoon Park	South Korea	Yeongyang Firefly Astronomical Observatory
Jason Pun	Hong Kong	The University of Hong Kong
Hideki Saito	Japan	Nagano City Museum
Rogel Mari Sese	Phillipines	Regulus SpaceTech/Science Education Institute
Yukiko Shibata	Japan	National Astronomical Observatory of Japan
Chu-wing So	Hong Kong	The University of Hong Kong
Toru Suyama	Japan	Nagano City Museum
Ah-chim Sul	South Korea	Office of International and Public Relations, Korea Astreonomy and Space science Institute
Kumiko Usuda-Sato	Japan	National Astronomical Observatory of Japan
Bartholomew Tsang	Hong Kong	Ho Koon Nature Education cum Astronomical Centre
Fumio Watanabe	Japan	Satellite Project Team, Shinshu University
Alan Yang	Taiwan	Taipei Astronomical Museum

Slide 1:

Globe at Night - Sky Brightness Monitoring Network

User Workshop Tokyo, Japan - Jan 7-9, 2015

Project background
The Globe at Night - Sky Brightness Monitoring Network

Dr Jason Chun-Shing PUN (潘振聲),
Dr Chu-Wing SO & Ryan W.Y. LEUNG,
The University of Hong Kong

Slide 2:

The Globe at Night - Sky Brightness Monitoring Network

- The **Globe at Night** program (http://www.globeatnight.org/)
  - an international citizen-science campaign to raise public awareness of the impact of light pollution
  - inviting citizen-scientists to measure their night sky brightness and submit their observations from a computer or smart phone

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Globe at Night - Sky Brightness Monitoring Network

Slide 3:

The Globe at Night - Sky Brightness Monitoring Network

- **The Globe at Night – Sky Brightness Monitoring Network project**
  - Our team has been studying light pollution in Hong Kong by through measuring the night sky brightness (NSB) since 2003.
  - We conducted a citizen-science NSB measurement campaign between 2007 – 2009.
  - It was succeeded by a comprehensive NSB monitoring network in 2010 (NSN, Please refer to Dr So's talk)
  - This project was initiated as a University of Hong Kong Knowledge Exchange (KE) program "**Promoting light pollution education and research worldwide**"

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Globe at Night - Sky Brightness Monitoring Network

Slide 4:

The Globe at Night - Sky Brightness Monitoring Network

- **The Globe at Night – Sky Brightness Monitoring Network project**
  - Endorsed by the IAU Executive Committee Working Group for the IYL as a **major Cosmic Light program**
  - In the award letter from IAU, it states "**Suggestions were to coordinate ... with others who are pursuing the educational aspect in other regions**."
  - Built on the successful Globe at Night participation model, we hope to establish a worldwide night sky brightness monitoring network (NSN).

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Globe at Night - Sky Brightness Monitoring Network

Slide 5:

The Globe at Night - Sky Brightness Monitoring Network

- **The Globe at Night – Sky Brightness Monitoring Network project**
  - Partners (a quickly expanding list):
    - IAU Office for Astronomy Outreach,
    - National Astronomical Observatory of Japan (NAOJ),
    - HKU,
    - Globe at Night,
    - Ho Koon Nature Education cum Astronomical Centre,
    - ……
  - Project website: http://globeatnight-network.org/

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Globe at Night - Sky Brightness Monitoring Network

Slide 6:

The Globe at Night - Sky Brightness Monitoring Network

- **The Globe at Night – Sky Brightness Monitoring Network program**
  - Set up a global night sky brightness monitoring network using the commercial available meter SQM-LE for long term monitoring of light pollution.
  - A real time map of light pollution available on the project website.

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Globe at Night - Sky Brightness Monitoring Network

The Globe at Night - Sky Brightness Monitoring Network

- **Target groups**

  1. Astronomical community: Professionals, amateurs, planetarium and observatory staff

  2. Environmental community: Ecological professionals (e.g. specialists on insects, birds, nocturnal marine species, etc), environmental enthusiasts, environmental advocates

  3. Education community: students and teachers of astronomy, planetary science, and environmental science

  4. General public: government officials, policy makers, opinion leaders, citizen-scientists

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Light pollution

- Light Pollution is the improper use of artificial outdoor lightings which leads to adverse effects on the environment.
- 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.
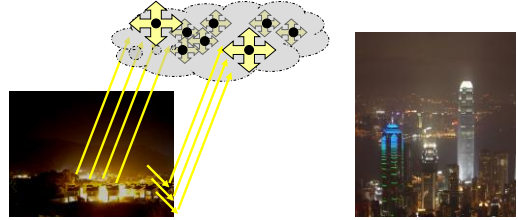
8 — User Workshop — Tokyo, Japan - Jan 7-9, 2015 — COSMIC LIGHT — Globe at Night - Sky Brightness Monitoring Network

The Earth at Night (2012)

Image courtesy of NASA Earth Observatory/NOAA NGDC

9 — User Workshop — Tokyo, Japan - Jan 7-9, 2015 — COSMIC LIGHT — Globe at Night - Sky Brightness Monitoring Network

The Earth at Night – Hong Kong (2012)
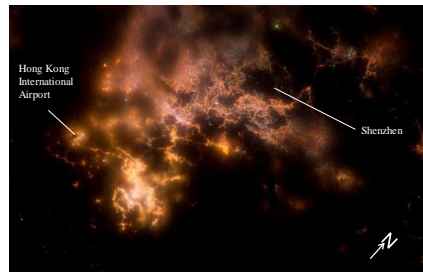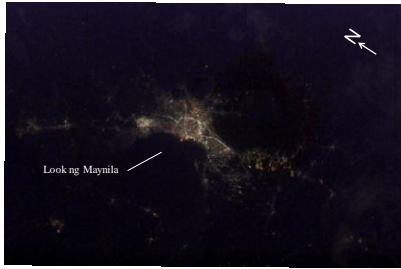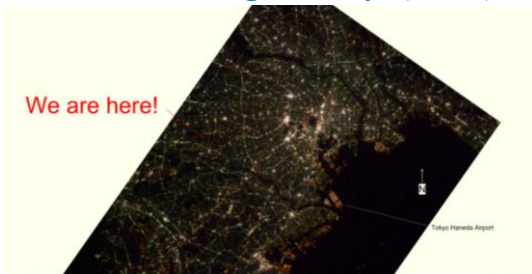
Hong Kong International Airport

Shenzhen

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

10 — User Workshop — Tokyo, Japan - Jan 7-9, 2015 — COSMIC LIGHT — Globe at Night - Sky Brightness Monitoring Network

The Earth at Night – Taiwan (2014)

New Taipei City

Pingtung

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

11 — User Workshop — Tokyo, Japan - Jan 7-9, 2015 — COSMIC LIGHT — Globe at Night - Sky Brightness Monitoring Network

The Earth at Night – Taipei (2012)
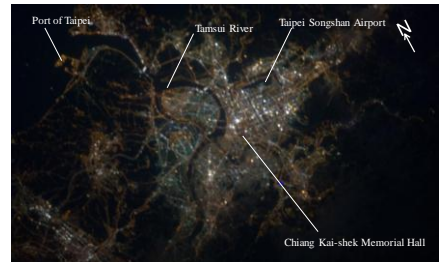
Port of Taipei

Tamsui River

Taipei Songshan Airport

Chiang Kai-shek Memorial Hall

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

12 — User Workshop — Tokyo, Japan - Jan 7-9, 2015 — COSMIC LIGHT — Globe at Night - Sky Brightness Monitoring Network

The Earth at Night – Korea (2014)

Pyongyang

Seoul

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

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Globe at Night - Sky Brightness Monitoring Network

The Earth at Night – Seoul (2004)

Han River

Yellow Sea

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

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Globe at Night - Sky Brightness Monitoring Network

The Earth at Night – Manila (2003)

Looking Maynila

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

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Globe at Night - Sky Brightness Monitoring Network

The Earth at Night – Tokyo (2008)

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

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Globe at Night - Sky Brightness Monitoring Network

The Earth at Night – Tokyo (2008)

We are here!

Tokyo Haneda Airport

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

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Globe at Night - Sky Brightness Monitoring Network

Light pollution & Night Sky Brightness

- Adverse effects of light pollution:
  - Health: light trespass, light nuisance
  - Environmental: nocturnal species, unbalance ecological systems
  - Energy: light not targeted at your eyes → wasted energy
  - Astronomical: skyglow / "overglow" from urban lighting

- Skyglow increases the night sky brightness
  → decrease the brightness contrast of the night sky
  → reduce the number of star visible by naked eye
  → reduce the accuracy of astronomical observations

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Globe at Night - Sky Brightness Monitoring Network

Slide 19

Measuring Light Pollution

- Globe at Night (and other similar programs)
  - counting of number of stars visible in certain constellation

Magnitude 1 Chart

Magnitude 7 Chart
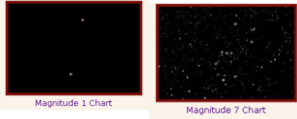
Some environmental pressure group in Hong Kong measures the street light level using luxmeters.

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Slide 20

Measuring Light Pollution

"Star-counting" survey

- Advantages:
  - Large geographical & temporal coverages with low cost
  - Light pollution conditions near places of human activities
  - Wide spread of the dark sky conservation message
- Disadvantages:
  - Photometric error is very large (± 1.2 mag arcsec^{-2}) (Kyba et al. 2013)

GaN a huge success as a citizen-science campaign

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Slide 21

Measuring Night Sky Brightness (NSB)

- Astronomical technique   (our different settings in 2003-07)

16" f/5.7 OGS RC telescope

70mm f/6.8 TeleVue Pronto refracting telescope + 2" diagonal

2" V-band filter + Starlight Xpress MX916 CCD

S+O

PDC

P+M

2" V-band filter + focal reducer + SBIG ST8 CCD

GP equatorial mount eyepiece adapter + 1.25" V-band filter + Nikon Coolpix 4500 DC

GP equatorial mount

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Slide 22
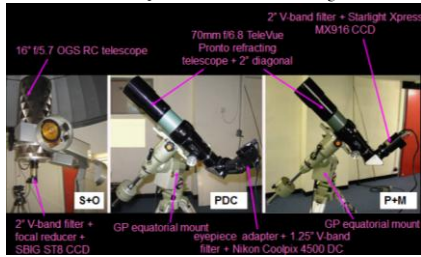
Measuring Night Sky Brightness (NSB)

- Astronomical technique (photometry)

Flowchart:

observatory

telescope + CCD camera

imaging Landolt (2009) standard star fields

transformed NSB & colors

moonlight correction (if any)

color transformation equations

extract NSB

data pre-processing (dark & flat-field)

color transformation coefficients

aperture photometry

standard zenith NSB

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Slide 23

Measuring Night Sky Brightness (NSB)

CCD photometry

- Advantages:
  - Photometric error is very small (<0.1 mag arcsec^{-2})
  - Multiple bands measurement (if used with a filter wheel)
  - Easy comparison with historical records
- Disadvantages:
  - High cost (trained personnel, sophisticated equipment)
  - Limited geographical & temporal coverages
  - Challenging to do in an urban setting

A key to success is to reduce the "cost"

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Slide 24

Measuring Night Sky Brightness (NSB)

- **Hand-held devices** from advancement of solid-state sensor:
  - DigiLum luminance meter, Mark Light Meter, Sky Quality Meter (SQM), etc
  - Smartphone app:

Loss of the Night

Dark Sky Meter

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Measuring Night Sky Brightness (NSB)

Handheld devices

- Advantages:
  - Fairly accurate (± 0.1 mag arcsec^{-2})
  - Low cost ($\sim$ USD 300 per unit) and ease of usage
  - High data sampling frequency (several seconds)
  - Can work effectively in both urban and rural environments
- Disadvantages:
  - Single and non-standard wavelength passband (though the SQM magnitude is gaining popularity in light pollution circles)
  - Only accurate near zenith(?)

Measuring Night Sky Brightness (NSB)

Handheld devices

- We believe an international SQM network provides the best compromise for cost, ease-of-use, geographical coverage, and temporal monitoring.
- From personal experience: While to the public the success of the project may depend on the data quantity (minimizing the dead-time), *maintaining data quality is more important*.
- E.g., the maintenance of the equipment (meter + shielding), a uniform and scheduled calibration scheme across the project, minimize data collected with "non-night-sky" factors not documented. (More on these in Dr So's talks)

Let's work together to preserve our dark sky!

Thank you!

Slide 1

Globe at Night - Sky Brightness Monitoring Network

User Workshop Tokyo, Japan - Jan 7-9, 2015

Project background –
The Hong Kong Night Sky Brightness Monitoring Network (NSN)

Dr SO Chu-wing
The University of Hong Kong

Slide 2

Hong Kong Night Sky Brightness Monitoring Network (NSN)

- **A city-wide survey of the light pollution conditions in the city of Hong Kong**
  - **Long-term study of the night sky brightness (NSB) in an urban metropolis**
    - Established in May 2010
    - What is the overall light pollution condition in Hong Kong?
    - How does the night sky brightness vary with location?
    - How does the night sky brightness change with time (monthly, nightly)?
    - How much does artificial lighting affect the night sky?
    - What is relation between cloud coverage and the night sky brightness (cloud-NSB study)?
    - What is relation between moonlight and the night sky brightness (moon-NSB study)?
  - **Platform for disseminating light pollution information and public outreach**
  - **Information for the government in drafting of outdoor lighting usage regulations**

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Slide 3

Measuring NSB by SQM-LE

- Sky Quality Meter – Lens Ethernet (SQM-LE)
- Ethernet connectivity
- Light sensor: TAOS TSL237 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
- Gives NSB in the unit of mag arcsec^{-2}
- Claimed accuracy of ±0.1 mag arcsec^{-2}
- Calibrated by the manufacturer before shipment
  - had not been calibrated to accurately measure a night sky darker than 23 mag arcsec^{-2}
- The same device used in the current Globe At Night network project

Figure source: Unihedron

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Slide 4

Measuring NSB by SQM-LE

peak ~540 nm
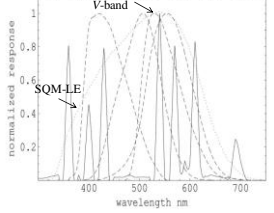
FWHM ~240 nm

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

(Cinzano 2005)

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Slide 5

Measuring NSB by SQM-LE

V-band

SQM-LE

- 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 (Puschnig et. al. 2014)

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)

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Slide 6

Measuring NSB by SQM-LE

FWHM ~20°

Angular response of SQM-LE in log (left) and linear (right) scales.

(Cinzano 2007)

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Slide 7

Measuring NSB by SQM-LE

SQM-LE (fixed to the cover)
weatherproof housing (with reflective surface)
circular glass window
power adopters for devices
power timer switch
3G modem
ventilation fans
ventilation fans
power inlet
3G router

SQM-LE points to zenith (within the housing)
mounting frame
cloud sensor
weather station
mounting pole
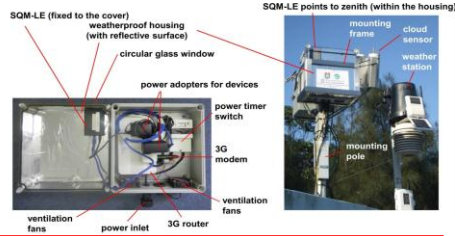
The housing uses in NSN was different from that for the current Globe At Night network project

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Slide 8

The use of 3G mobile network for data collection in NSN

- 3G SIM card (with fixed IP address) + modem + router
- **Advantages:**
  - Request real-time data actively from server
  - Save cost on:
    - routing cables from indoor to outdoor
    - putting a computer on site
  - Increase flexibility on station selections
- **Disadvantages:**
  - Need a larger housing to house equipment
  - Higher setup cost (for fix IP address & housing)
  - Need network coverage
  - Unstable network in extreme weathers

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Slide 9

NSN stations

10 urban stations
6 rural stations
2 not-classified stations
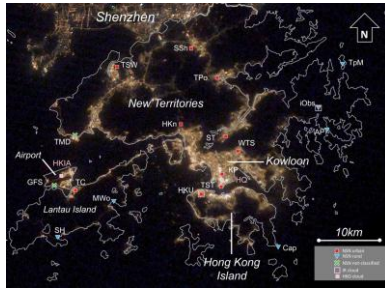
Image courtesy of Image Science and Analysis Laboratory, NASA-Johnson Space Center, The Gateway to Astronaut Photography of Earth

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Slide 10

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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Slide 1

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

Dr SO Chu-wing
The University of Hong Kong

Slide 2

Before data collection

Globe at Night - Sky Brightness Monitoring Network

Slide 3

Selection of a good NSB monitoring location

- Outdoor, open space
- Without direct lighting nearby

Globe at Night - Sky Brightness Monitoring Network

Slide 4

Selection of a good NSB monitoring location

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

Globe at Night - Sky Brightness Monitoring Network

Slide 5

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.

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Slide 6

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.

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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.

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Examples of good NSB monitoring locations - rooftop

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Examples of good NSB monitoring locations – wall corner

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Materials needed

- A set of Sky Quality Meter-LE+H(+PoE)
  - Already owned or provided by NAOJ
- 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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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
  - Details on mounting will be shown in "Configuration and installation of SQM-LE unit" session

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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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Slide 13

After data collection

Slide 14

What can you see (from raw data)?

Raw NSB covering Feb 2013 @ HKU

Slide 15

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

Cloud?? Twilight?? Window aging?? Program bug??
Human activity?? Raining?? Moonlight?? Sensor error??

Slide 16

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

Slide 17

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

Slide 18

Sunlight / twilight

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

solar altitude, NSB, astro. twilight end at 19:45, sunset at 18:30

Unphysical NSB readings

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

NSB = -41 mag !
NSB = 37.3 mag !
NSB = 22.5 mag !
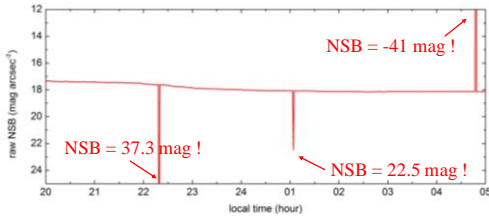
Aging of optics – SQM-LE's filter

- 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

frosted filters   new filters
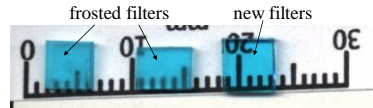
Light attenuation of glass window of Unihedron housing

- 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

Non-routine lighting events

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

"normal" light curve
brighter readings when someone turned on light
affected light curve
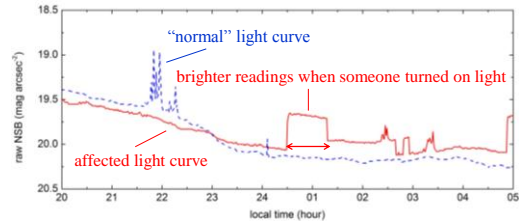
Non-routine lighting events

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

Light-off led to ~1 mag drop in NSB in the city center

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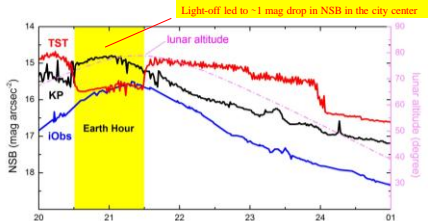
* Earth Hour is held annually by WWF which encourages individuals, communities, households and businesses to turn off their non-essential lights during 20-30-21:30, as a symbol for their commitment to the planet.

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 .

"normal" drops
Late night of holiday was brighter
"holiday" drops
New Year's Eve
27-28 Dec 2013
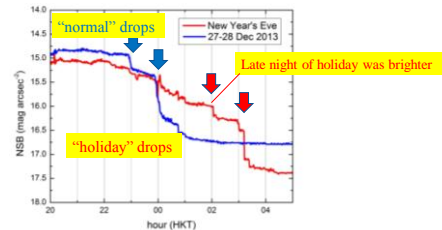
Moonlight

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

New Moon: $F = 0$
Full Moon: $F = 1$
Moon at horizon: altitude = 0 deg
Moon at zenith: altitude = 90 deg

ΔV is the approximate contribution of direct and scattering moonlight to the sky with NSB 21.2 mag arcsec^{-2}.
(Krisciunas & Schaefer 1991)
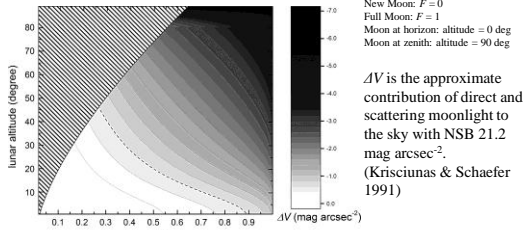
Moonlight

- 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.

moonlight contribution
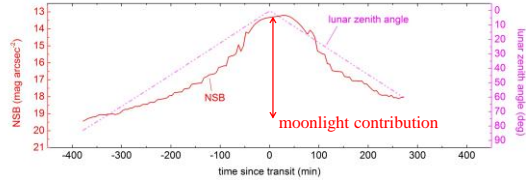
Scattered city light from clouds

- 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

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, Ts-a is the temperature difference between the ambient and the sky in IR

cloudy

clear
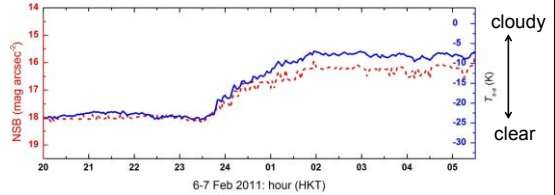
Non-night-sky events

- 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.

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/

Slide 1

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Configuration and installation of SQM-LE unit

Dr SO Chu-wing
The University of Hong Kong

Slide 2

1. Unboxing a package of Sky Quality Meter-LE+H+POE
2. Establish connection for configuration
3. SQM-LE configuration: **Lantronix Device Installer (LDI)**
4. SQM-LE configuration: **XPort**
5. SQM-LE configuration: **Unihedron Device Manager (UDM)**
6. Communication test of SQM-LE
7. Selection of a mounting location for SQM-LE
8. Installation of SQM-LE
9. SQM-LE cabling
10. SQM-LE testing

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Slide 3

1. Unboxing a package of Sky Quality Meter-LE+H+POE
2. Establish connection for configuration
3. SQM-LE configuration: **Lantronix Device Installer (LDI)**
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Slide 4

1. Unboxing a package of Sky Quality Meter-LE+H+POE

cross-over cable (for direct connection only)

Power-over-Ethernet (PoE)

ethernet cable

Sky Quality Meter(SQM)-LE

Power adapter SQM-LE

Housing (H)

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Slide 5

1. Unboxing a package of Sky Quality Meter-LE+H+POE
2. Establish connection for configuration
3. SQM-LE configuration: **Lantronix Device Installer (LDI)**
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Slide 6

2. Establish connection for configuration

2.1 Follow the example of cabling below :

SQM-LE

network switch / hub / router

Ethernet cable
*** not connect by wifi **

To power adapter

Ethernet cable

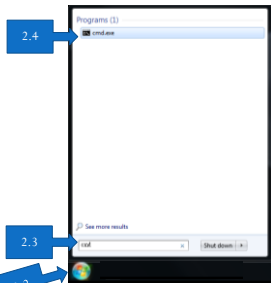Caution：
Please use wired connection for the desktop/laptop but not wifi.

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Slide 7

2. Establish connection for configuration

2.2 click

2.3 type in "cmd"
2.4 run "cmd.exe"

2.4
2.3
2.2

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Slide 8

2. Establish connection for configuration

2.5 Type "ipconfig" then pass enter
2.6 Look for the values of "Subnet Mark" and "Default Gateway" under "Ethernet adaptor Local Area Connection". These information will be used for configuring SQM-LE.
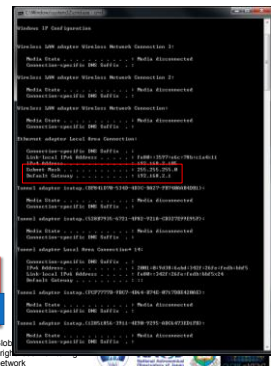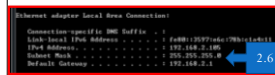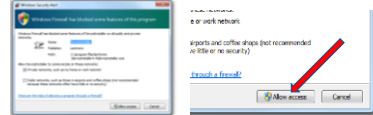

2.6

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Slide 9

1. • Unboxing a package of Sky Quality Meter-LE+H+POE
2. • Establish connection for configuration
3. • SQM-LE configuration: **Lantronix Device Installer (LDI)**
4. • SQM-LE configuration: **XPort**
5. • SQM-LE configuration: **Unihedron Device Manager (UDM)**
6. • Communication test of SQM-LE
7. • Selection of a mounting location for SQM-LE
8. • Installation of SQM-LE
9. • SQM-LE cabling
10. • SQM-LE testing

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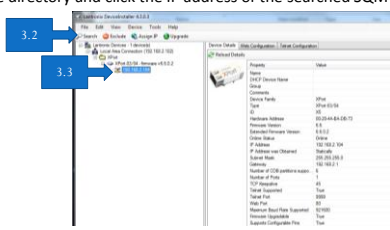
Slide 10

3. SQM-LE configuration: Lantronix Device Installer (LDI)

3.1 download and install then run **Lantronix Device Installer (LDI)**:

Web setup (1.3 MB, requires internet access):

http://unihedron.com/projects/darksky/cd/SQM-LE/windows/LDI/setup.exe

Stand-alone setup (70 MB, no internet access required to install):

http://unihedron.com/projects/darksky/cd/SQM-LE/windows/LDI/setup_di_x86x64cd_4.4.0.2RC3.exe

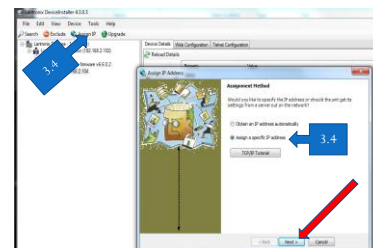Select "Allow access" when asked for firewall permission:

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Slide 11

3. SQM-LE configuration: Lantronix Device Installer (LDI)

3.2 run **LDI** > click "Search" near upper right to search for SQM-LE connected (the name is "Xport-XX", where XX is a number)

3.3 expand the directory and click the IP address of the searched SQM-LE device

3.2
3.3

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3. SQM-LE configuration: Lantronix Device Installer (LDI)

3.4 click "Assign IP" > "Assign a specific IP address" > "Next" to configure the IP address of SQM-LE

3.4
3.4

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•2

Slide 13

3. SQM-LE configuration: Lantronix Device Installer (LDI)

3.5 Configure the IP address according to the values of subnet mask and gateway of the network in the installation location:

Example	A (used as an example in the rest of the document)	B	C
network in the installation location:			
Subnet Mask#	255.255.255.0	255.255.255.0	255.255.0.0
Default Gateway^	192.168.2.1	192.168.0.1	192.168.0.1
configuring SQM-LE via LDI ("IP Settings") :			
IP address*	192.168.2.104	192.168.0.100	192.168.0.200
Subnet mark#	255.255.255.0	255.255.255.0	255.255.0.0
Default gateway^	192.168.2.1	192.168.0.1	192.168.0.1

* do not use the IP address which is occupied by other network devices (e.g. network printer) for SQM-LE
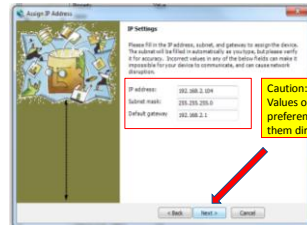\# subnet mask of SQM-LE should be the same as that of the network adopted
^ default gateway of SQM-LE should be the same as that of the network adopted (i.e., router's IP)

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Slide 14

3. SQM-LE configuration: Lantronix Device Installer (LDI)

3.6 Input the IP address, Subnet mark, and Default gateway then click "Next" > "Assign"

3.7 wait for the processing (a couple of minute)

Caution: Values on this image are for preference only. Do not use them directly.

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Slide 15

1. Unboxing a package of Sky Quality Meter-LE+H+POE
2. Establish connection for configuration
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5. SQM-LE configuration: **Unihedron Device Manager (UDM)**
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Slide 16

4. SQM-LE configuration: XPort

4.1 click again the IP address of SQM-LE > click "Web Configuration" tab > click

4.2 leave the login username and password blank. Click "OK" to enter the XPort page.

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Slide 17
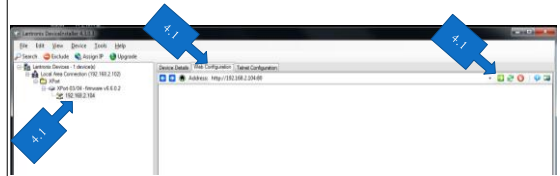
4. SQM-LE configuration: XPort

4.3 click "Connection" under "Channel 1" on the right manual. Select "**With Any Character**" for the "Active Connect" under "Active Connection"
4.4 set the "Local Port" as **10001**
4.5 set the "Remote Port" as **80**
4.6 set "Remote Host" as (to be announced in the workshop)
4.7 set "Inactivity Timeout" under "Disconnect Mode" as **0:2**
4.8 click "OK"
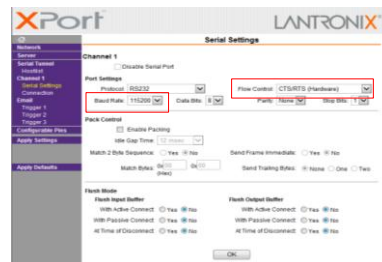4.9 click "Apply Settings" then wait for the process to complete
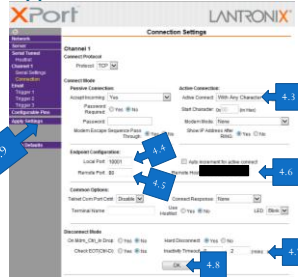
For additional details, please refer to pages 43 to 44 of the manual:
http://unihedron.com/projects/darksky/cd/SQM-LE/SQM-LE_Users_manual.pdf

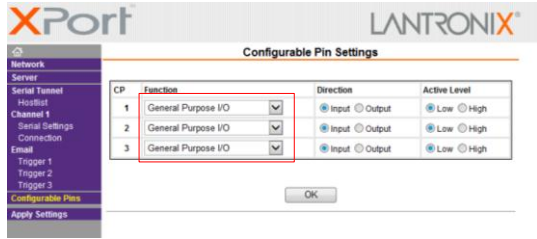
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Slide 18

4. SQM-LE configuration: XPort

Other settings of XPort (for information only)

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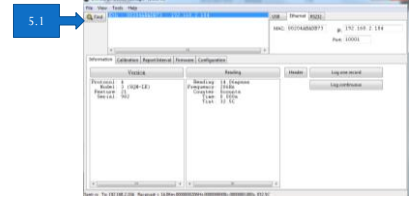
4. SQM-LE configuration: XPort

Other settings of XPort (for information only)

Configurable Pin Settings

CP	Function	Direction	Active Level
1	General Purpose I/O	Input / Output	Low / High
2	General Purpose I/O	Input / Output	Low / High
3	General Purpose I/O	Input / Output	Low / High

OK

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1. Unboxing a package of Sky Quality Meter-LE+H+POE
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5. SQM-LE configuration:
Unihedron Device Manager (UDM)

5.1 download and install **Unihedron Device Manager (UDM)**:

http://unihedron.com/projects/darksky/cd/SQM-LE.html

> run > click "Find" near upper right

5.1

For additional details, please refer to pages 20 to 34 of the manual:
http://unihedron.com/projects/darksky/cd/SQM-LE/SQM-LE_Users_manual.pdf

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5. SQM-LE configuration:
Unihedron Device Manager (UDM)

5.2 click "Report interval" tab, input "30" as below

5.2

Input "30" then click "E/R"

For additional details, please refer to pages 20 to 34 of the manual:
http://unihedron.com/projects/darksky/cd/SQM-LE/SQM-LE_Users_manual.pdf

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5. SQM-LE configuration:
Unihedron Device Manager (UDM)

5.3 click "Get Report Interval Info"

5.3

Make sure that the values of "in EEPROM" and in RAM" are both 30

For additional details, please refer to pages 20 to 34 of the manual:
http://unihedron.com/projects/darksky/cd/SQM-LE/SQM-LE_Users_manual.pdf

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5. SQM-LE configuration:
Unihedron Device Manager (UDM)

5.4 click "Configuration" tab, then capture and send the screen to us for information.
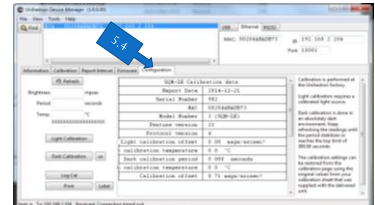
5.4

For additional details, please refer to pages 20 to 34 of the manual:
http://unihedron.com/projects/darksky/cd/SQM-LE/SQM-LE_Users_manual.pdf

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Slide 25

1. • Unboxing a package of Sky Quality Meter-LE+H+POE
2. • Establish connection for configuration
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7. • Selection of a mounting location for SQM-LE
8. • Installation of SQM-LE
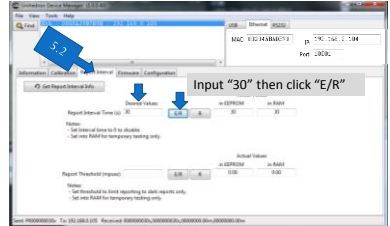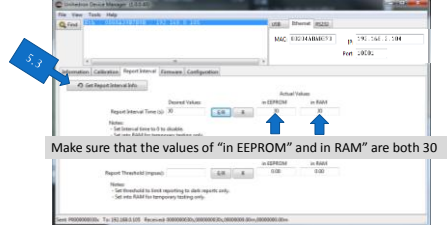9. • SQM-LE cabling
10. • SQM-LE testing

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Slide 26

6. Communication test of SQM-LE

Conduct a communication test before installing the SQM-LE to outdoor:

Please contact Dr So:
Tel: 852 9447 2120 or
email: socw@connect.hku.hk or
skype: sochuwing

Install the SQM-LE to outdoor only when the communication is well established.
Once the "Interval Report" is running, avoid to get data from the device from software such as SQM reader or Unihedron Device Manager.

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Slide 27

1. • Unboxing a package of Sky Quality Meter-LE+H+POE
2. • Establish connection for configuration
3. • SQM-LE configuration: **Lantronix Device Installer (LDI)**
4. • SQM-LE configuration: **XPort**
5. • SQM-LE configuration: **Unihedron Device Manager (UDM)**
6. • Communication test of SQM-LE
7. • Selection of a mounting location for SQM-LE
8. • Installation of SQM-LE
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Slide 28

7. Selection of a mounting location for SQM-LE

- Open outdoor space, such as rooftop
- Avoid artificial light nearby shining directly on SQM-LE
  - The light collective cone of SQM-LE of about 20 degrees away from the zenith

artificial light stand **inside** the SQM-LE light cone

artificial light stand **outside** the SQM-LE light cone

20°

SQM-LE

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Slide 29

7. Selection of a mounting location for SQM-LE

Make sure that there is no artificial light, including those be turned on automatically or manually in the evening, within the region of SQM-LE light collective cone

Railings
(possible mounting point of SQM-LE)

artificial light (from the building)

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Slide 30
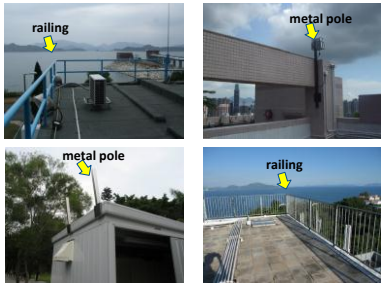
7. Selection of a mounting location for SQM-LE

- Safely first: make sure that the device is safe under severe weather conditions.
- Mount the device to a metal pole or railing.
  - **The sensor of SQM-LE should point directly to the zenith (directly "above" the location)**
- The ethernet cable can be routed from indoor to outdoor for power and internet connections.
  - Plug the base unit of the PoE to the AC power supply and internet connection appropriately in indoor. Make sure that both power and internet connections are already on throughout the night.

After selecting a mounting location, take pictures showing the environment of the location and email pictures to Dr So for him to check whether the location is acceptable.

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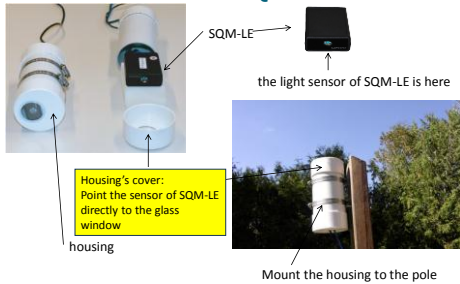
30

7. Selection of a mounting location for SQM-LE

railing
metal pole
metal pole
railing

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1. • Unboxing a package of Sky Quality Meter-LE+H+POE
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8. Installation of SQM-LE

SQM-LE

the light sensor of SQM-LE is here

Housing's cover:
Point the sensor of SQM-LE directly to the glass window

housing

Mount the housing to the pole

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8. Installation of SQM-LE

The output voltage of the terminal unit of PoE should be set as 5V but NOT 12V

set as 5V but NOT 12V

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8. Installation of SQM-LE

Insert the SQM-LE and PoE's terminal unit to the housing

Cover the lid

Make sure that there is no gap between the sensor and the glass window!

Put the SQM and PoE inside the box

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8. Installation of SQM-LE

Point the sensor of SQM-LE directly to the glass window
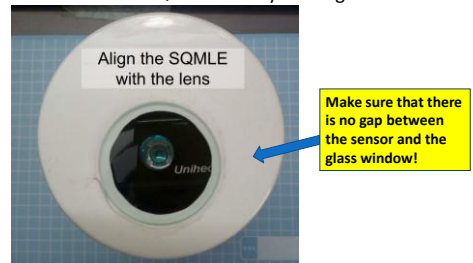
Align the SQMLE with the lens

Make sure that there is no gap between the sensor and the glass window!

Unihed

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8. Installation of SQM-LE
Device supporting (optional)

8. Installation of SQM-LE
Mount the housing to the pole

cable gland
to seal the opening for ethernet cable

8. Installation of SQM-LE
Mount the housing to the pole

stainless steel
hose / Jubilee clip

8. Installation of SQM-LE
Mount the housing to the pole

electrical tape (prefer outdoor quality)
to seal the cover

cable ties (prefer outdoor quality)

1. Unboxing a package of Sky Quality Meter-LE+H+POE
2. Establish connection for configuration
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8. Installation of SQM-LE
9. SQM-LE cabling
10. SQM-LE testing

9. SQM-LE cabling

Inside the housing   SQM-LE

Cloud server on the internet (via port 80)

power cord   ethernet cable

PoE terminal unit

set the output voltage as 5V

Cat 5 ethernet cable running from indoor to outdoor

PoE base unit   ethernet cable

network switch / hub / router

timer switch

power supply of PoE base unit

indoor

•7

1. • Unboxing a package of Sky Quality Meter-LE+H+POE
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4. • SQM-LE configuration: **XPort**
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10. • SQM-LE testing

10. SQM-LE testing

After the completing the above steps:

Please contact Dr So

Tel: 852 9447 2120 or
email: socw@connect.hku.hk or
skype: sochuwing

Slide 1

Globe at Night - Sky
Brightness Monitoring
Network

User Workshop Tokyo, Japan - Jan 7-9, 2015

Non-night-sky events

Dr SO Chu-wing
The University of Hong Kong

Slide 2

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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Slide 3

Non-night-sky events

- The above factors that polluted the NSB light curves were 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 "Introduction to data analysis" session.

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Slide 4

Sunlight / twilight

- Sunlight saturates the sensor of SQM-LE
  - Can be easily avoided by removing data taken before sunset or after sunrise.
  - Get the sunset and sunrise timings from official meteorological agency of your country or region, or
    http://www.timeanddate.com/worldclock/sunrise.html

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Slide 5

Sunlight / twilight

- Sunrise and sunset calculator:
  http://www.timeanddate.com/worldclock/sunrise.html

- Tokyo, Japan — Sunrise, sunset and daylength, December 2014

December 2014 - Sun in Tokyo

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Slide 6

Sunlight / twilight

- Twilight
  - Can be avoided by excluding data taken outside the astronomical dark period.
    - Astronomical dusk / dawn
      - Sun reaches 18+ degrees below the horizon
    - Astronomical dark period
      - The time between astronomical dusk and dawn.
    - Sunlight is also avoided by excluding data taken outside astronomical dark period
  - Timing of astronomical dark period can change significantly over the year, especially in locations with high latitude.

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Sunlight / twilight

- Get the timings from official meteorological agency of your country or region, or
  http://www.timeanddate.com/worldclock/sunrise.html
- Sunrise and sunset calculator:
  http://www.timeanddate.com/worldclock/sunrise.html

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Unphysical NSB readings

- Can be easily avoided by excluding data with NSB <= 10 or NSB >= 23 during data extraction.
  - Or define your own limits based on the actual situation
- Details will be discussed in "Introduction to data analysis" session.

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Aging / light attenuation of optics

- The aging of SQM-LE's filter is assumed to be absent for recent models.
- The light attenuation of glass window can be adjusted by offsetting raw NSB data by -0.11 mag arcsec^{-2}.
  - The size and the evolution of the offset need further studies.

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Non-routine lighting events

- Database table *non_night_sky_events* records the occurrence of non-night-sky events, including non-routine lighting events
- **All SQM-LE users are invited to maintain a good record of non-night-sky events related to their location(s).**

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Non-routine lighting events

1. Click table "*non_night_sky_events*"
2. Click "*New item*"
3. Provide the following information for each events
4. Click "*Save*"

Select data | **Show structure** | Alter table | New item

Column	Type	Comment
id	mediumint(9) *Auto Increment*	
site	varchar(10) *NULL*	
start_date_time	datetime *NULL*	local time
end_date_time	datetime *NULL*	local time
category	int(10) unsigned *NULL*	
detail	text	
remark	text	
reading_affected	enum('yes','no')	

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Non-routine lighting events

- Each type of non-night-sky event has a category ID with two digits
- Non-night-sky events are categorized into 9 main categories (1st digit):

category	event		category	event
10-19	installation		60-69	activity
20-29	network		70-79	astronomy
30-39	power		80-89	weather
40-49	mounting		90-99	others
50-50	maintenance			

- ID x9 in each main category is reserved for "other"
- Categorization are listed in the database table *non_night_sky_events_category* which will be updated from time to time

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Non-routine lighting events

- The field "*reading_affected*" only has two values: *yes*, *no*
- If you believe that the NSB readings were affected by the non-night-sky event, click "*yes*". For examples:
  - In a public event, the external lighting on the rooftop where the SQM-LE is installed were turned-on. The sky readings were affected by this event.
- If you believe that the NSB readings were NOT affected by the non-night-sky event, click, click "*no*". For examples:
  - During a private observation, no external lighting was turned-on. The sky readings were not affected by this event.
  - The mounting of SQM-LE was disassembled temporary for maintenance works in daytime. The sky readings at night were not affected by this event.

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Non-routine lighting events

- **All SQM-LE users are invited to maintain a good record of non-night-sky events related to their location(s).**
- For example, suppose there was a public stargrazing event conducted on the NAOJ rooftop where the SQM-LE is installed from 8pm to 10pm last night. External lighting were switched on.
  - site = *AOJ*
  - start_date_time = *2015-01-07 19:30:00* (including preparation time)
  - end_date_time = *2015-01-07 22:30:00* (including time on tidying up)
  - category = *61*

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Non-routine lighting events

- Detail = A *public stargrazing event hosted by Mr ABC…External lighting were turned-on sometime*
- Remark = *same rooftop as SQM-LE installation*
- reading_affected = *yes*

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Non-routine lighting events

- Points to note:
  - If you are unsure whether a particular event is "non-night-sky", please also record it and make some remarks.
  - Please provide details on each event as much as possible.
  - If no category fit, input x9, e.g. 49 for "other" event related to mounting.
  - Please make a record as soon as you know it
    - Accept future events
    - Accept daytime events
  - Please check "non-night-sky" events input by others if you are analyzing light curves of that particular locations.
  - Exclude data taken during certain non-night-sky events before analysis.

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Moonlight

- Unless for moonlight-NSB analysis, the effect of moonlight can be easily avoided by underlining data taken when the Moon is above the horizon (or above certain lunar brightness).
- Get the moonset and moonrise timings from official meteorological agency of your country or region, or

http://www.timeanddate.com/worldclock/moonrise.html

- If you need more data on the Moon…
  - e.g., Alcyone Ephemeris software (not freeware): http://www.alcyone.de/

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Moonlight

- Moonrise and moonset calculator

http://www.timeanddate.com/worldclock/moonrise.html

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Lunar eclipse

- Unless for moonlight-NSB analysis, the effect of lunar eclipse can be easily avoided by <u>excluding data taken during lunar eclipses.</u>
- Get the eclipse timings from official meteorological agency of your country or region, or
- http://www.timeanddate.com/eclipse/

Scattered city light from clouds

- The effect of scattered city light from clouds can be easily avoided by <u>excluding data taken when the sky is cloudy.</u>
- Alternatives:
  - Averaging a huge amount of data covering multiple sky conditions
  - Analyzing "flat" light curves
- Cloud amount can be estimated by manual observation, cloud sensor, or ceilometer.
- Get the cloud amount data from official meteorological agency of your country or region, if any.
- An alternative is to install an all sky camera near the NSB observing station
  - e.g., The Moonglow Technologies All Sky Cam:
    http://www.moonglowtech.com/products/AllSkyCam/

To be studied...

- Other natural phenomena (**you are invited to study their effects on NSB and share your ideas / findings among us!**)
  - Rain
  - Snow
  - Lightning
  - Aurora
  - Bird and its dropping
  - Insect
  - …
- Program bugs

Introduction to data analysis of Globe at Night - Sky Brightness Monitoring Network

Dr SO Chu-wing
The University of Hong Kong

Introduction to data analysis of Globe at Night Network

- NSB database
  - User login
  - Data structure
- Basic analysis
  - Statistics
  - Temporal variations of NSB
    - Short-term
    - Long-term
  - Geographical variations of NSB
    - Cross-city analysis

NSB database - User login

- All NSB data collected are obtainable from a database namely *iyl* via an user-friendly web-based interface *adminer*
  - IP address: (to be announced in the workshop/ later)
  - Login username: (to be announced in the workshop / later)
  - Password: (to be announced in the workshop / later)
- Database management system: MySQL
- Limited privileges

NSB database - Data structure

- The *iyl* database contains the following tables:
  - *sqmle_nsb_data_table*: the main table storing NSB data collected from all stations in *real-time*
  - *non_night_sky_events*: record of non-night-sky events
  - *non_night_sky_events_category*: list of category of non-night-sky events
- Normal user can only edit the *non_night_sky_events* table

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NSB database - User login

- Training dataset:
  - IP address: **http://** (to be announced in the workshop)**/iyl-adminer.php**
  - Login username: (to be announced in the workshop)
  - Password: (to be announced in the workshop)

NSB database - Data structure

- The training database contains the following tables:
  - *sqmle_nsb_data_table_training*
  - *non_night_sky_events_training*
  - *non_night_sky_events_category_training*
- They have the same data structure as the real one
- The table *sqmle_nsb_data_table_training* stores more than 340,000 entries:
  - 1 urban (HK1) and 1 rural (HK2) stations in Hong Kong
    - Cover multiple lunar cycles and different weather conditions in late-2012 and recent months
  - The recent data collected from Tokyo (AOJ) and Taipei (TAM) are also included

NSB database - Data structure

- Table *sqmle_nsb_data_table* has the following fields for each entry:

Column	Type
id	bigint(20) unsigned *Auto Increment*
created	datetime
received_utc	datetime
received_adjusted	datetime
sqmle_serial_number	int(11) *NULL*
nsb	double [9999]
sensor_frequency	double [0]
sensor_period_count	double [0]
sensor_period_second	double [0]
temperature	double [9999]
time_of_resend	int(11) [0]
device_code	varchar(255) *NULL*
request_time	datetime [0000-00-00 00:00:00]
status	enum('success','failure') [success]

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NSB database - Data structure

- Only the following fields are useful for basic analysis:

field	format	description
id	number	Unique ID of each entry
received_utc	YYYY-MM-DD HH:MM:SS	NSB data date & time in **UTC**
received_adjusted	YYYY-MM-DD HH:MM:SS	NSB data date & time in **local time**
nsb	number	Raw NSB value
device_code	character	Station code indicating the location
status	"success" or "failure"	Always select "success"

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Basic analysis

- Before conducting the analysis, we assumed:
  - Data collected during non-routine lighting events or on-site maintenance / servicing periods (i.e. events with *reading_affected* = yes) were removed
  - Sunlight affected data were avoided if needed
- Will be considered:
  - Excluding unphysical NSB readings
- Not considered yet:
  - Moonlight contribution
  - Scattered city light from clouds
  - Aging of SQM-LE's filter
  - Light attenuation of glass window
  - Other sources of error

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Basic analysis - Statistics

- *adminer* provides the following built-in functions to perform basic statistics:

function	target field(s)	description
avg	nsb	Calculate the average
count	id	Count the number of entry (sample size)
count distinct	(any)	Count the number of distinct entry (sample size)
max	nsb	Return the maximum
min	nsb	Return the minimum

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Basic analysis - Statistics

- Example 1:
  - Count the **sample size** collected from AOJ between 2014-12-24 17:00:00 and 2014-12-25 05:00:00 local time

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Basic analysis - Statistics

- Example 2:
  - Calculate the **average of NSB** collected from HK1 between 2012-11-29 21:00:00 and 2012-11-30 22:00:00 local time

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Slide 13

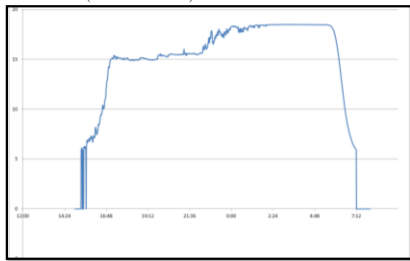# Basic analysis – Short-term temporal variations of NSB

- Aim: plot the NSB light curve of a particular night of a particular station to study the short-term time variation of NSB
- Example 3:
  - Time period (local time): 2014-12-20 15:00:00 - 2014-12-21 08:00:00
  - Location: AOJ

Slide 14

Basic analysis – Short-term temporal variations of NSB

- Export data to csv (or other formats)

Slide 15

Basic analysis – Short-term temporal variations of NSB

- Plot in Excel (or other software)

Slide 16

Basic analysis – Long-term temporal variations of NSB

- Aim: plot the nightly average NSB of a particular station to study the long-term time variation of NSB
- Example 4:
  - Date period: from 2012-10-01 to 2012-10-31
  - Time window (local time): from 20:00:00 to 05:00:00
  - Location: HK2
- Calculate the nightly average NSB by **MySQL commands** from the following template (after setting the above parameters, execute the calculation by copying and pasting the codes in the *SQL command* box):

Slide 17

Basic analysis – Long-term temporal variations of NSB

```
SELECT

DATE_FORMAT(DATE_SUB(received_adjusted, interval 12 hour),'%Y-%m-%d')
as date,
device_code as site, avg(nsb) as average_nsb, std(nsb) as std_nsb,
count(id) as smaple_size

FROM sqmle_nsb_data_table

WHERE
nsb >10 and nsb < 23 AND
device_code = 'HK2' AND
DATE_FORMAT(DATE_SUB(received_adjusted, interval 12 hour),'%Y-%m-%d')
between '2012-10-01' and '2012-10-31' AND
(DATE_FORMAT(received_adjusted,'%H:%i:%S') >= '20:00:00' or
DATE_FORMAT(received_adjusted,'%H:%i:%S') <= '05:00:00')

GROUP BY DATE_FORMAT(DATE_SUB(received_adjusted, interval 12
hour),'%Y-%m-%d')
ORDER BY received_adjusted;
```

Modify underline parameters

Slide 18

Basic analysis – Long-term temporal variations of NSB

- Export data to csv (or other formats)

2012-10-25	HK2	18.610386178861788	0.9441538417451565	492
2012-10-26	HK2	17.815496957403628	1.002082216816823	493
2012-10-27	HK2	16.94540489642188	0.6210215567208585	531
2012-10-28	HK2	16.867415254237297	1.0692015936683192	472
2012-10-29	HK2	16.688022727272724	0.7412746696381254	440
2012-10-30	HK2	17.048747433264897	0.3584100640221845	487
2012-10-31	HK2	16.519117043121145	1.5258796367906504	487

31 rows (0.541 s) Edit, EXPLAIN, Export

```
SELECT

DATE_FORMAT(DATE_SUB(received_adjusted, interval 12 hour),"%Y-%m-%d") as date,
device_code as site, avg(nsb) as average_nsb, std(nsb) as std_nsb, count(id) as :
```

Basic analysis – Long-term temporal variations of NSB

- Plot in Excel (or other software)

Basic analysis - Geographical variations of NSB - Cross-city analysis

- NSB would vary significantly among locations due to the difference in light pollution conditions
- Aim: study the geographic variations of NSB across different locations / cities from single-night light curves
  - Method: repeat the steps in example 3 for different stations then compare their light curves
- Cautions!
  - Effects of cloud / Moon would lead to completely different results
    - e.g., Station A (cloudy) vs station B (clear) => station A is brighter
      - => A is more light-polluted?
    - e.g., Station C (full Moon) vs station D (new Moon) => station C is brighter
      - => C is more light-polluted?