



Globe at Night - Sky  
Brightness Monitoring  
Network

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

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

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# Before data collection

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User Workshop  
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Globe at Night - Sky  
Brightness Monitoring  
Network

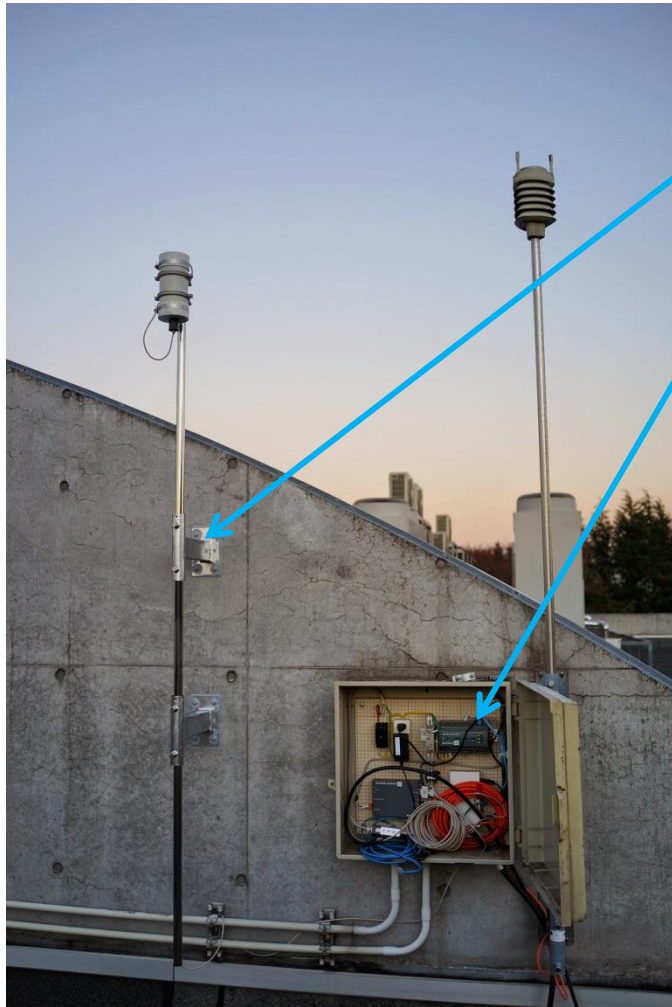


# Selection of a good NSB monitoring location

- Outdoor, open space
- Without direct lighting nearby



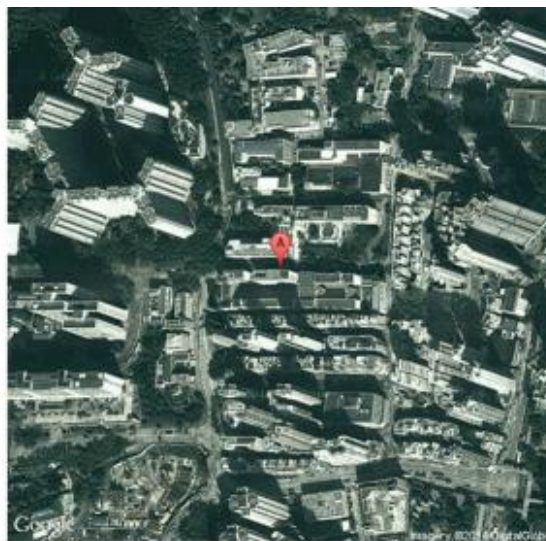
# Selection of a good NSB monitoring location



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

# 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.



# 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.

# 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.

# Examples of good NSB monitoring locations - rooftop





# Examples of good NSB monitoring locations – wall corner



# 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

# 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

# Operation of SQM-LE

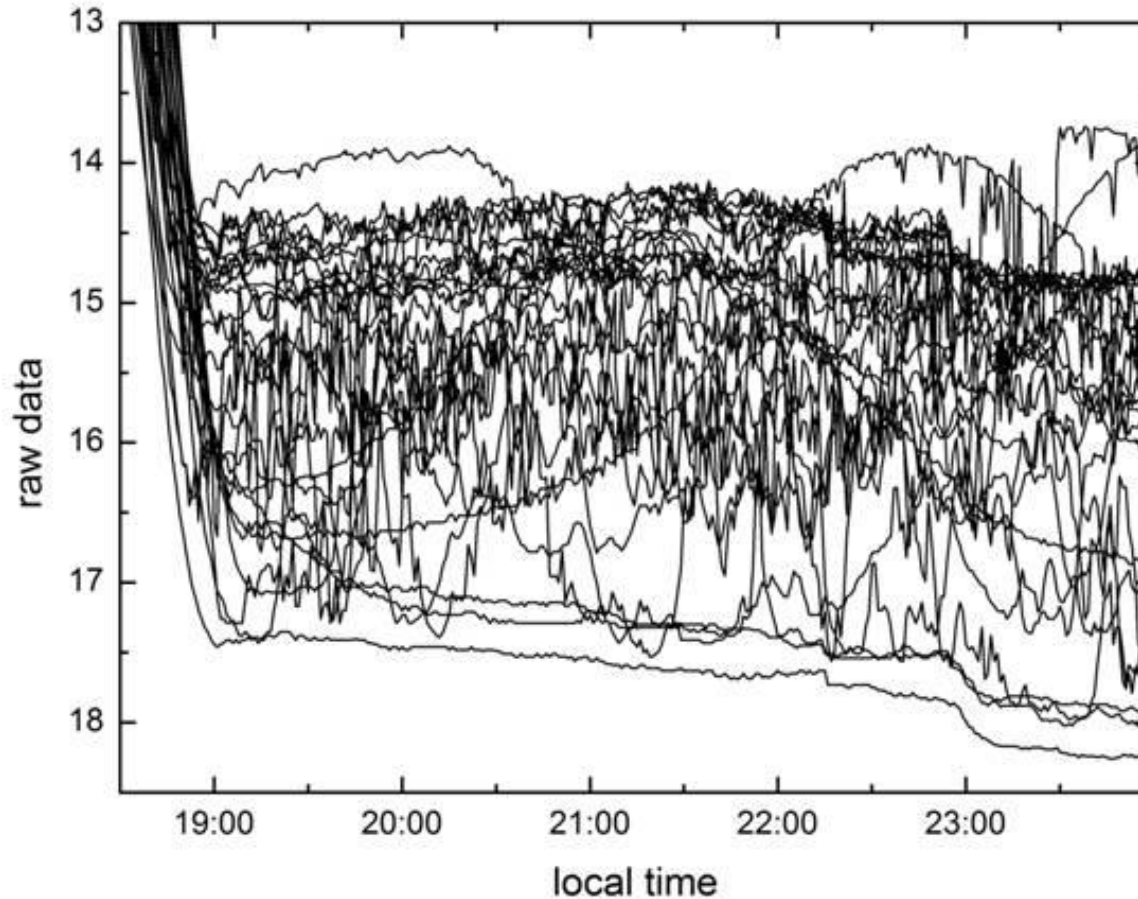
- Housing:
  - Weatherproof
  - Made in PVC
  - Length  $\sim$  20 cm
  - Weight  $\sim$  650 g
- Power:
  - Powered by “Power-over-Ethernet (PoE)”: 48V DC 400mA to 5 V DC (SQM-LE)
  - Power consumption  $<$  7 W
  - $<$  5.2kWh /month
- Data transfer:
  - $<$  5 MB / month
- Sensing (SQM-LE):
  - Remote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



# After data collection

# What can you see (from raw data)?

Raw NSB covering Feb 2013 @ HKU

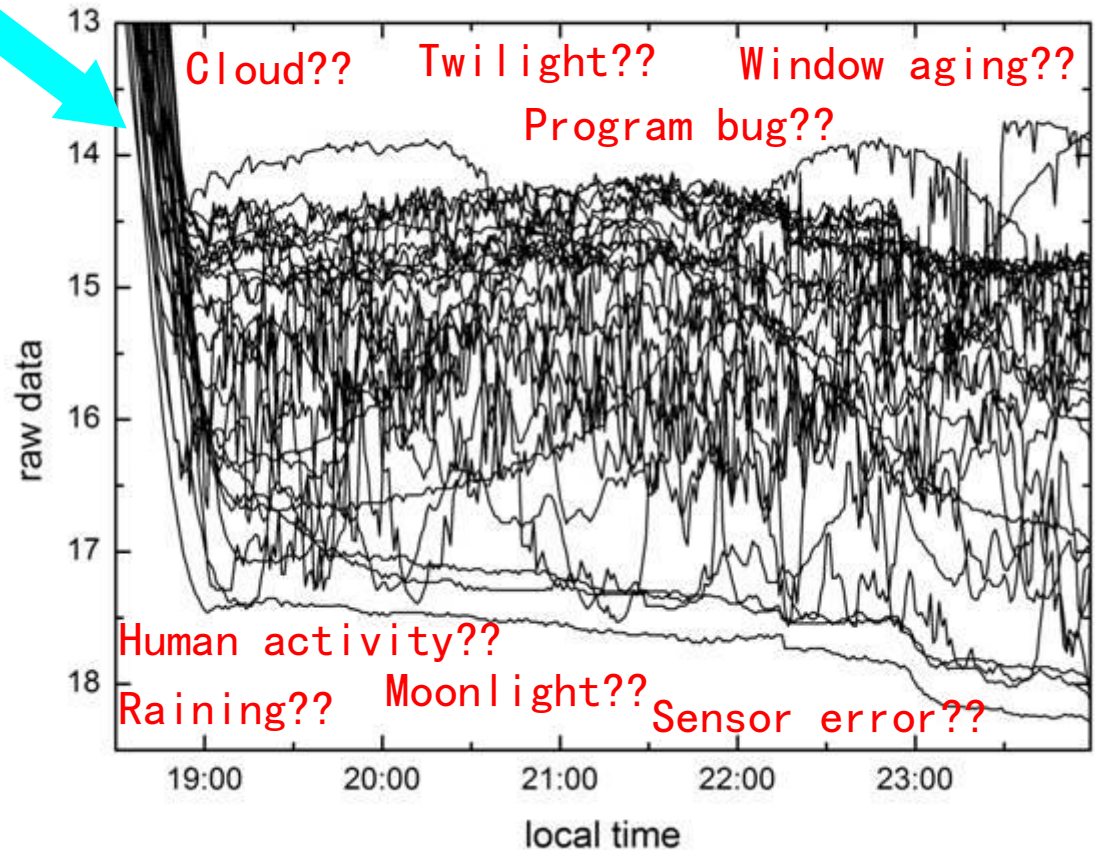


# Examples of NSN raw data

- 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



# Factors affected raw NSB data

- Sunlight / twilight
- Unphysical NSB readings
  - e.g.,  $\leq 10$  mag,  $\geq 23$  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

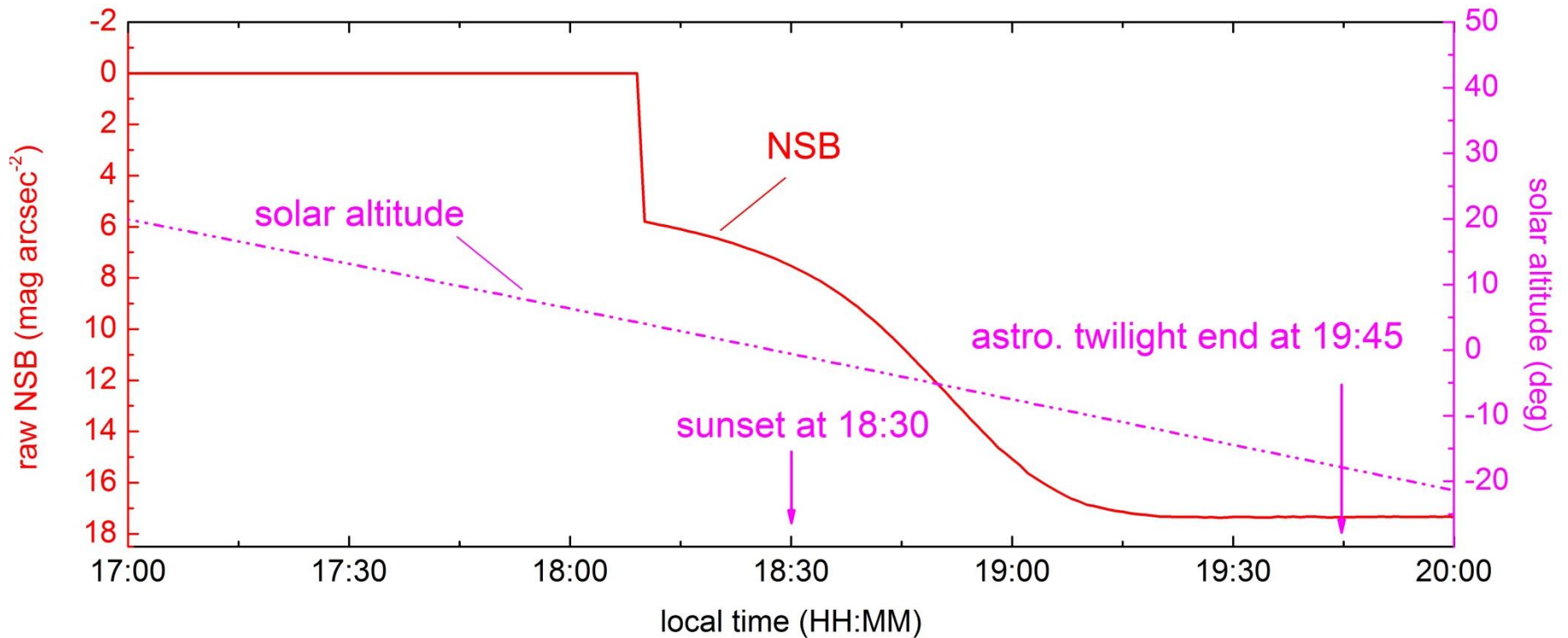


# Sunlight / twilight

- 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

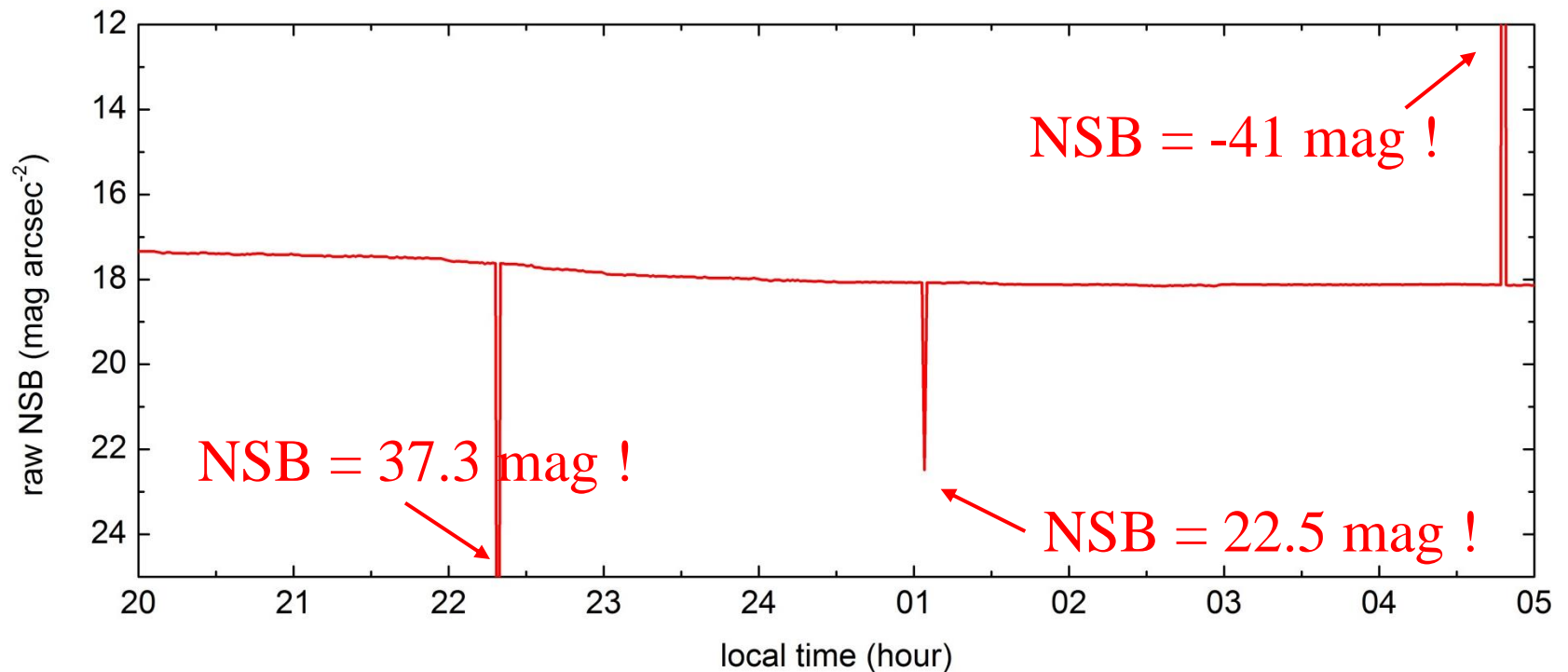
# Sunlight / twilight

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



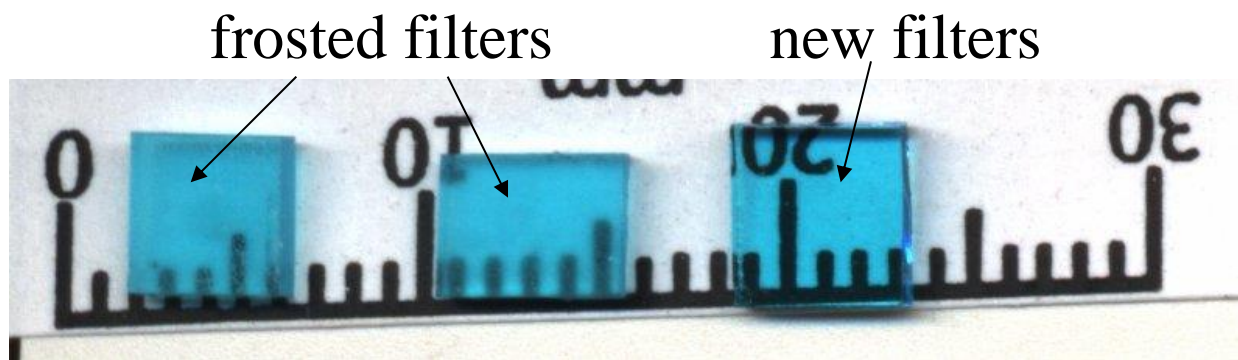
# Unphysical NSB readings

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



# 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





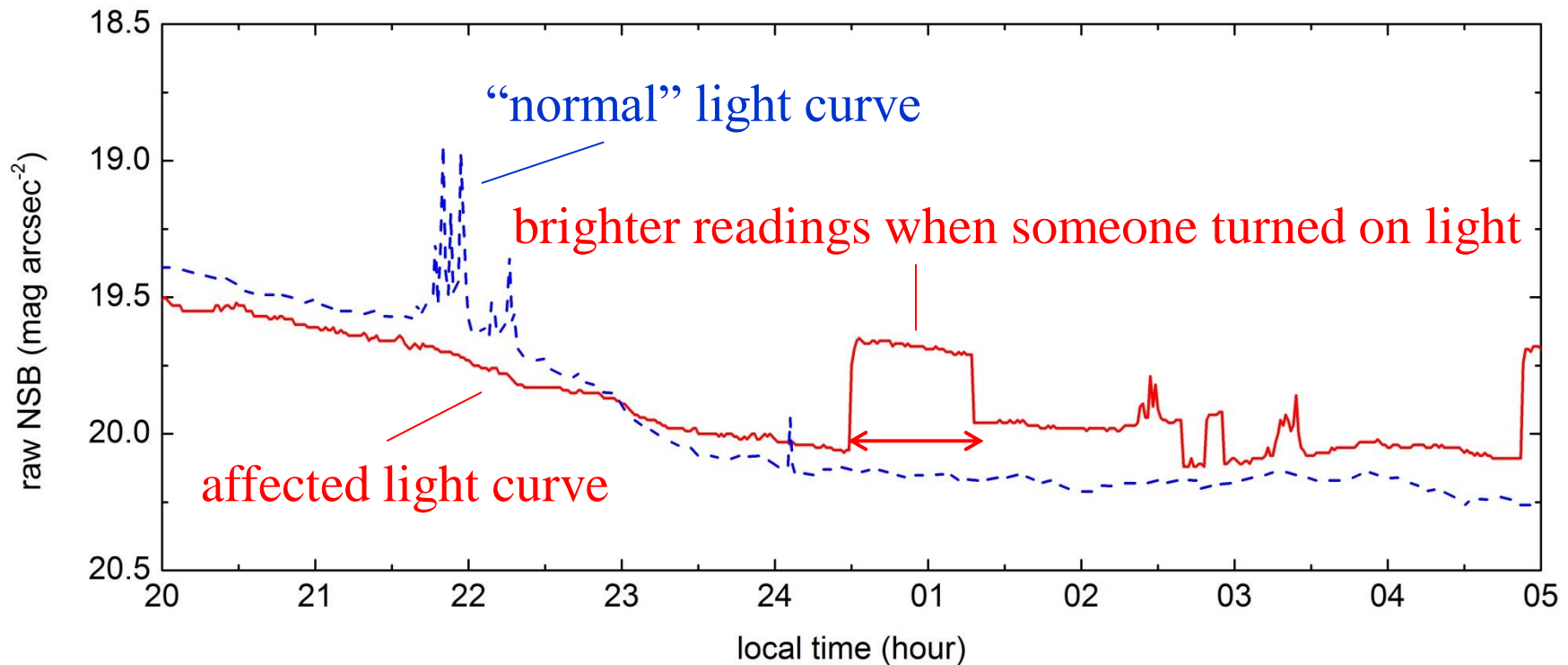
# Light attenuation of glass window of Unihedron housing



- 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

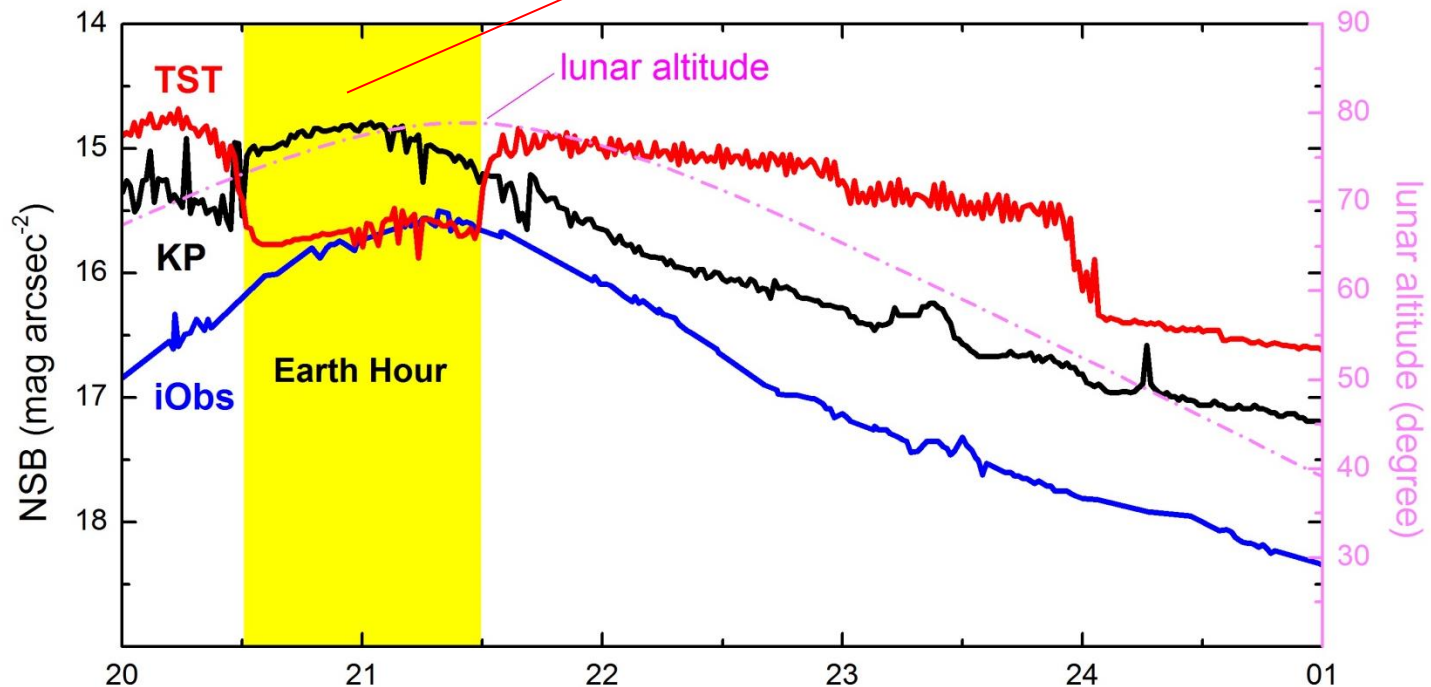
- The example red light curve below was affected by a stargazing event in a rural location during a moonless evening.



# 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.

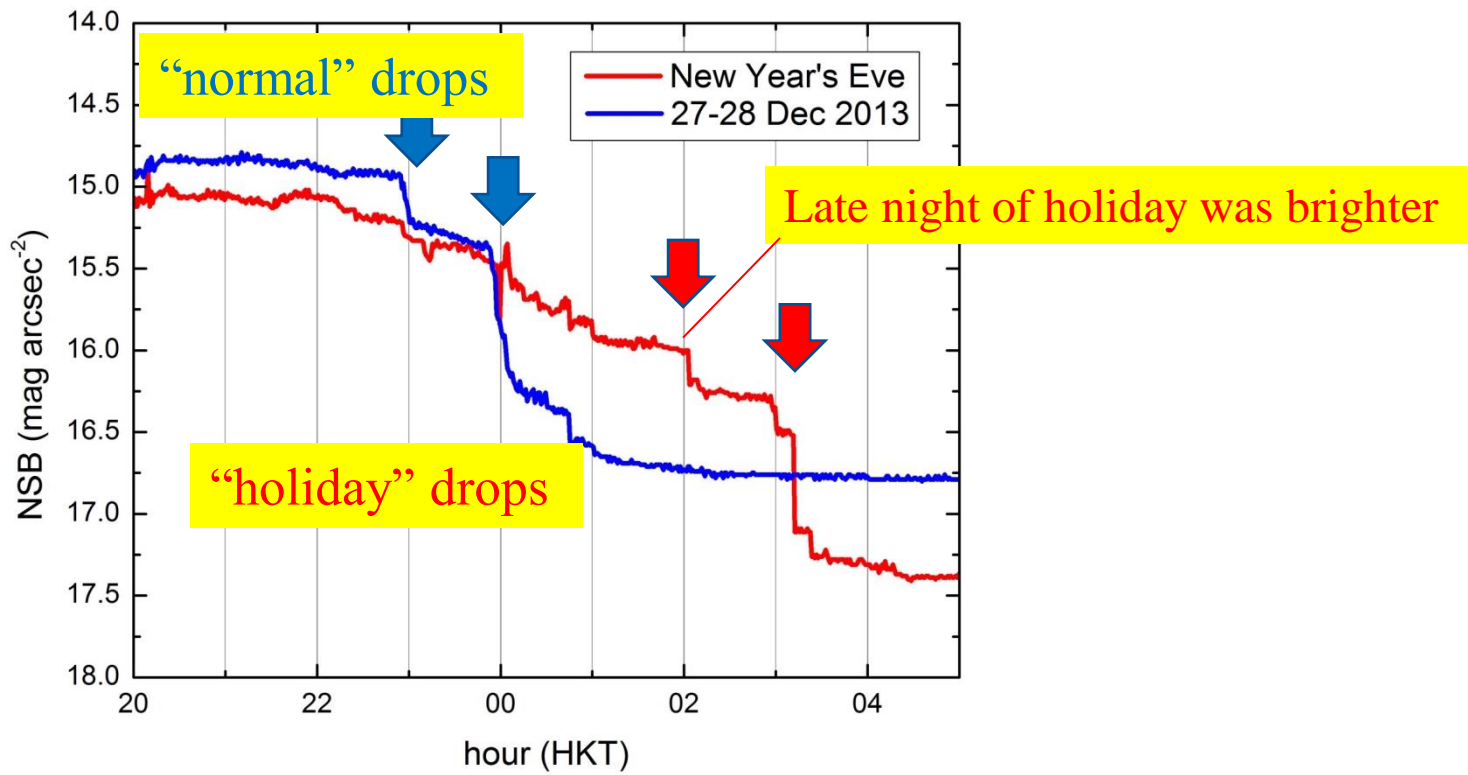
Light-off led to ~1 mag drop in NSB in the city center



\* 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

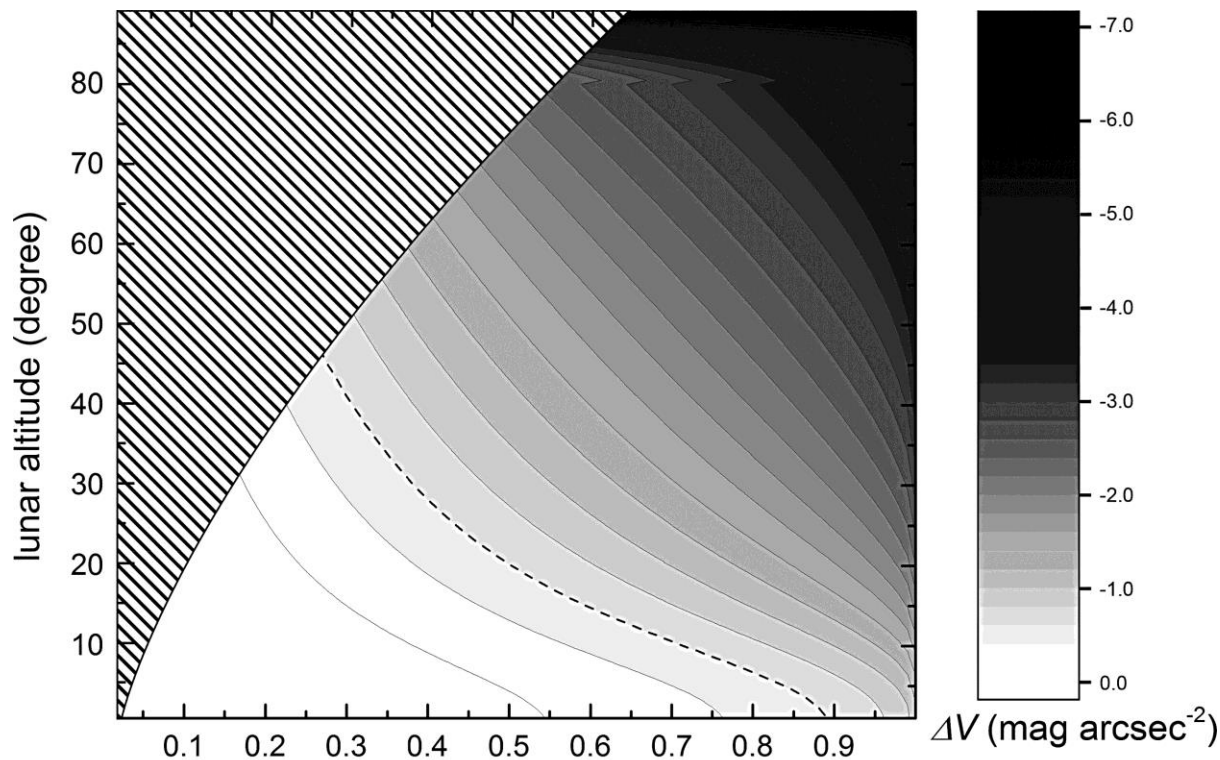
- The example red light curve below describes the variation of NSB in a urban location during 2013-14 New Year's Eve .





# Moonlight

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



New Moon:  $F = 0$

Full Moon:  $F = 1$

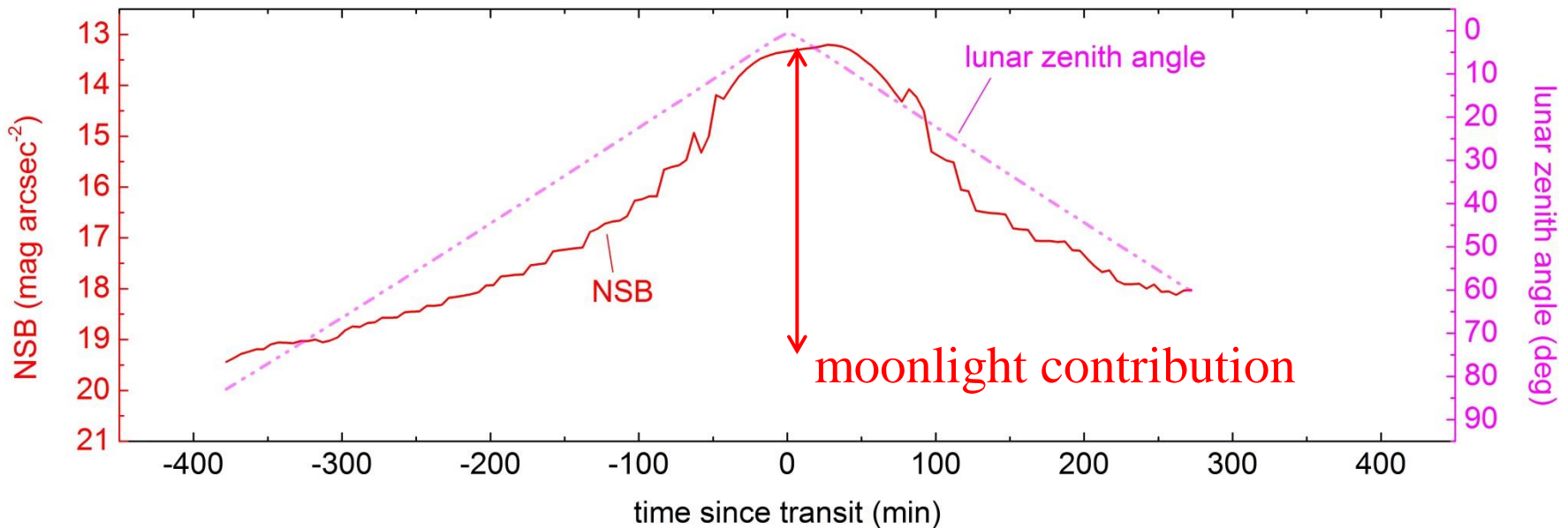
Moon at horizon: altitude = 0 deg

Moon at zenith: altitude = 90 deg

$\Delta V$  is the approximate contribution of direct and scattering moonlight to the sky with NSB 21.2 mag arcsec<sup>-2</sup>.  
(Krisciunas & Schaefer 1991)

# Moonlight

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

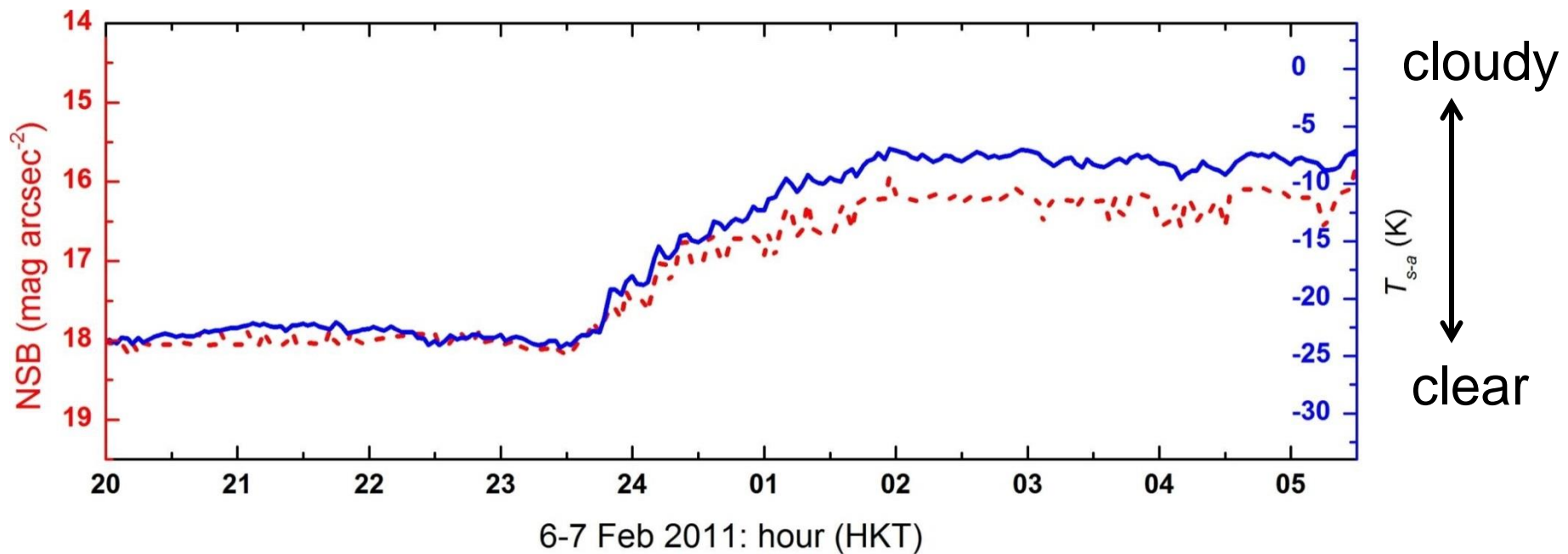


# Scattered city light from clouds

- 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,  $T_{s-a}$  is the temperature difference between the ambient and the sky in IR



# 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/>