Performance and Results from the Globe at Night – Sky Brightness Monitoring Network

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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.
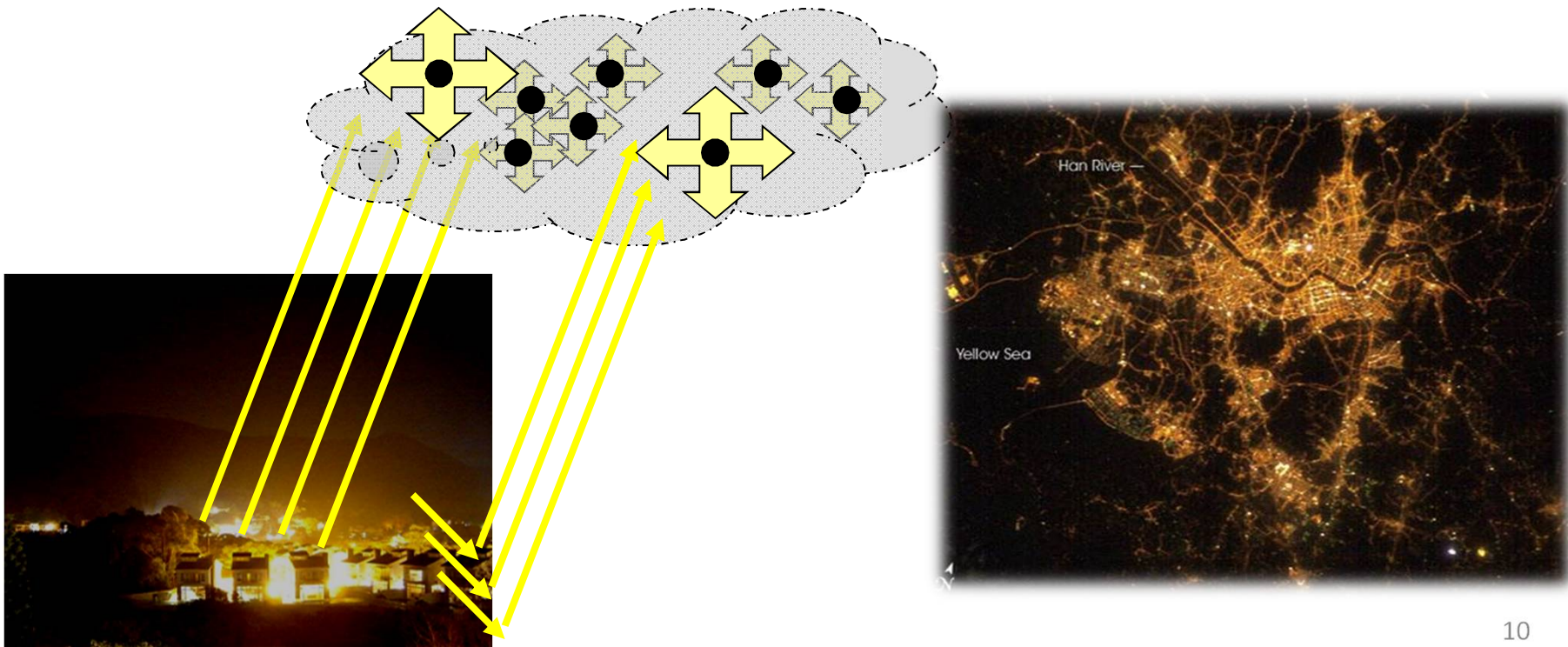
Light pollution and Night Sky Brightness (NSB)

- 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)

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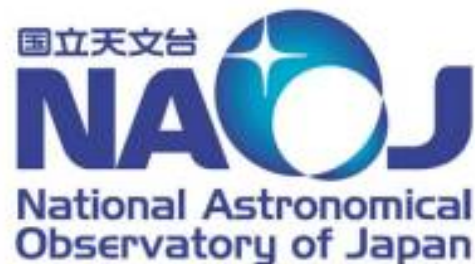
The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- 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!**

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

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

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

@ Chungbuk National University Observatory (CNUO)
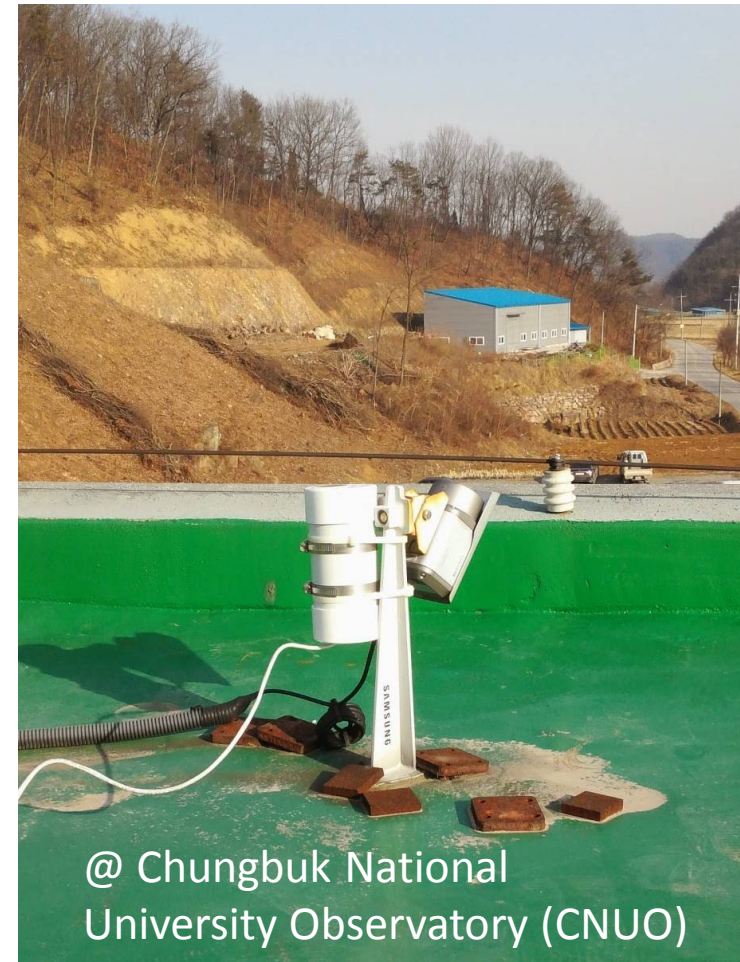
Sky Quality Meter – Lens Ethernet (SQM-LE)
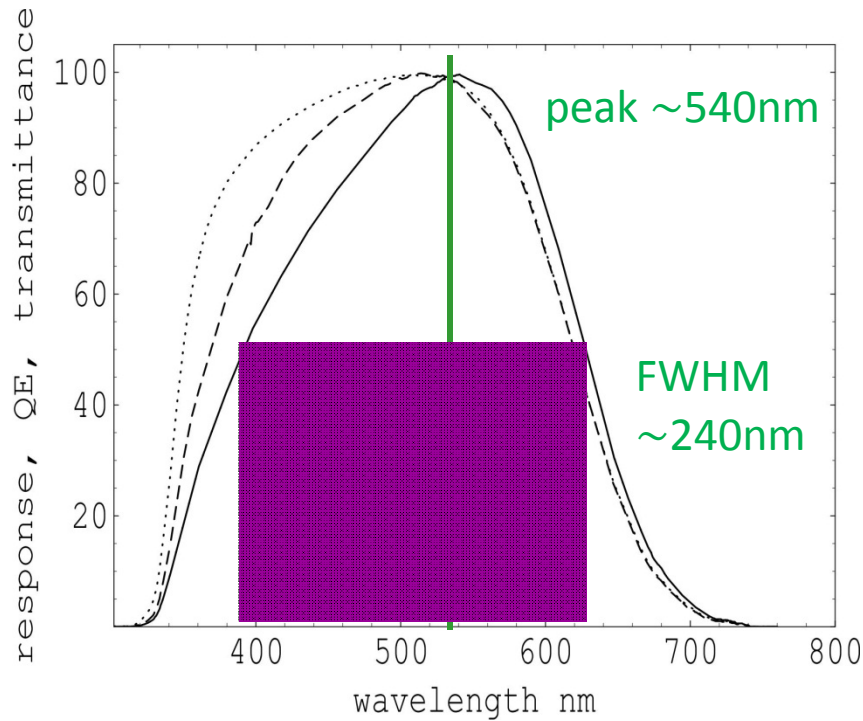
- Manufacturer: Unihedron (Canada)
- Light sensor: TAOS TSL237 High-Sensitivity Light-to-Frequency Converter
- Near-IR blocking filter: Hoya CM-500
- Size 3.6 x 2.6 x 1.1 in.
- Operates from 5-6V DC adapter
- Night sky brightness given in unit mag arcsec^{-2}
- Accuracy of ± 0.1 mag arcsec^{-2}
  - Calibrated by the manufacturer before shipment

Figure source: Unihedron

Methodology

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

(Cinzano 2005)
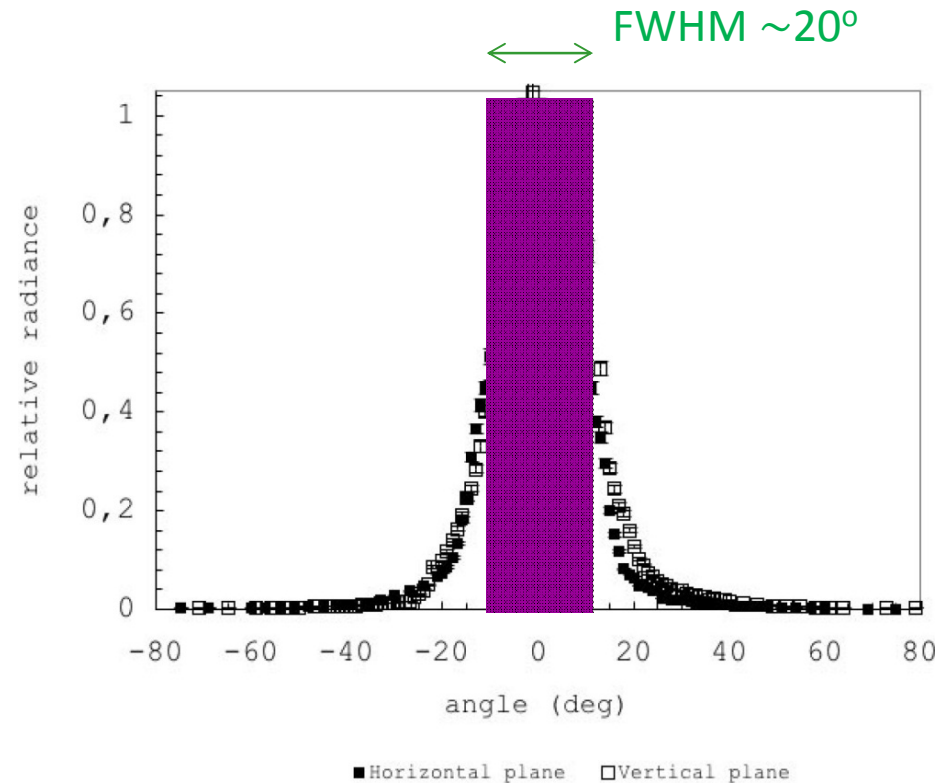
Angular response function of SQM-LE

(Cinzano 2007)

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

- Methodology and highlights:
  - Data
    - Live display of NSB on Google Maps
    - Sharing of data archive among stations
  - Easy to join
    - Materials needed: SQM-LE, housing, internet connection (minimal configuration), power supply, mounting
    - Minimal maintenance except troubleshooting on power or network sometime

The 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.

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)

Real time map here:
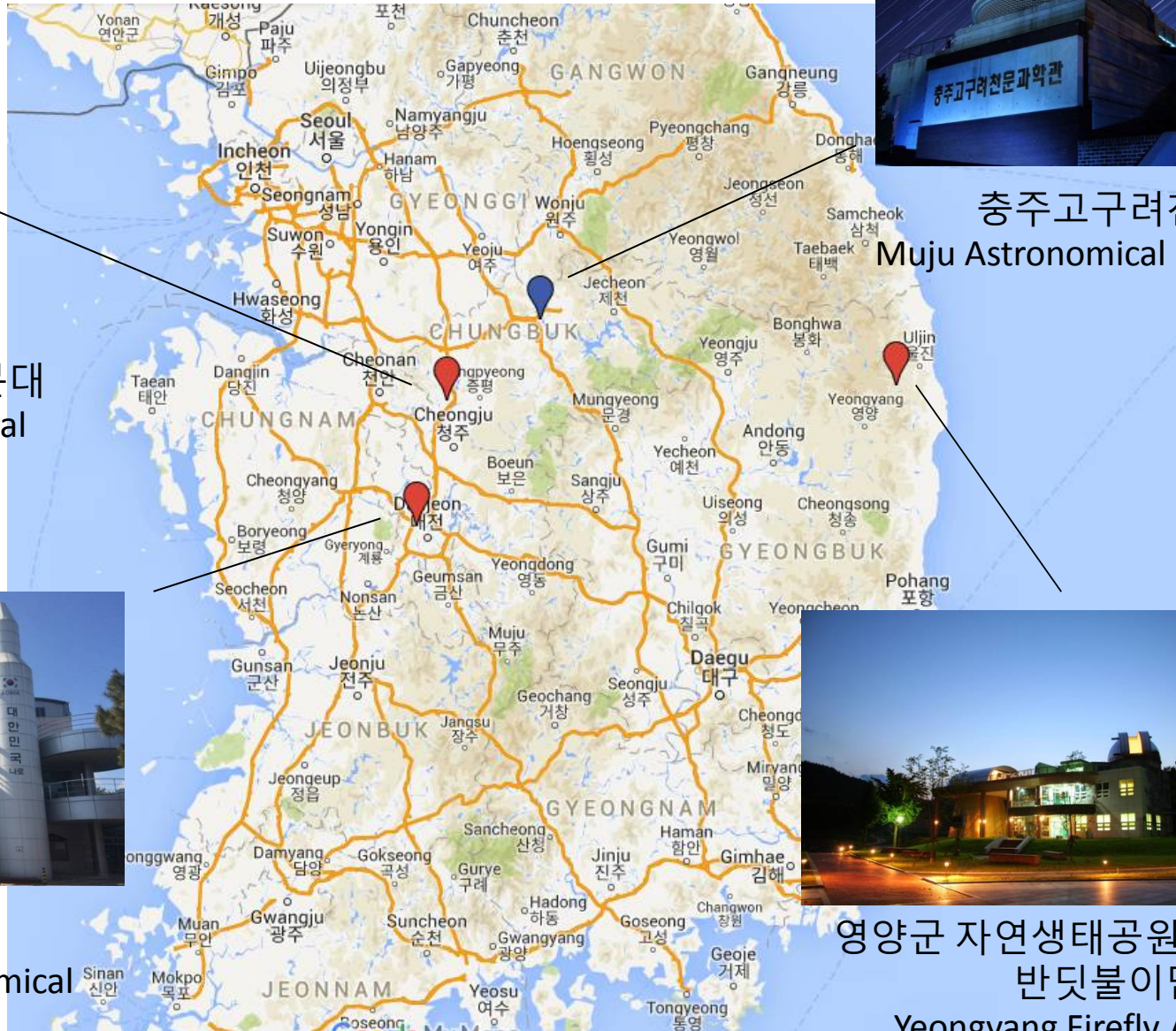http://globeatnight-network.org/map.html

GaN-MN in Korea

충북대학교 천문대
Chungbuk National University Observatory

충주고구려천문과학관
Muju Astronomical Observatory
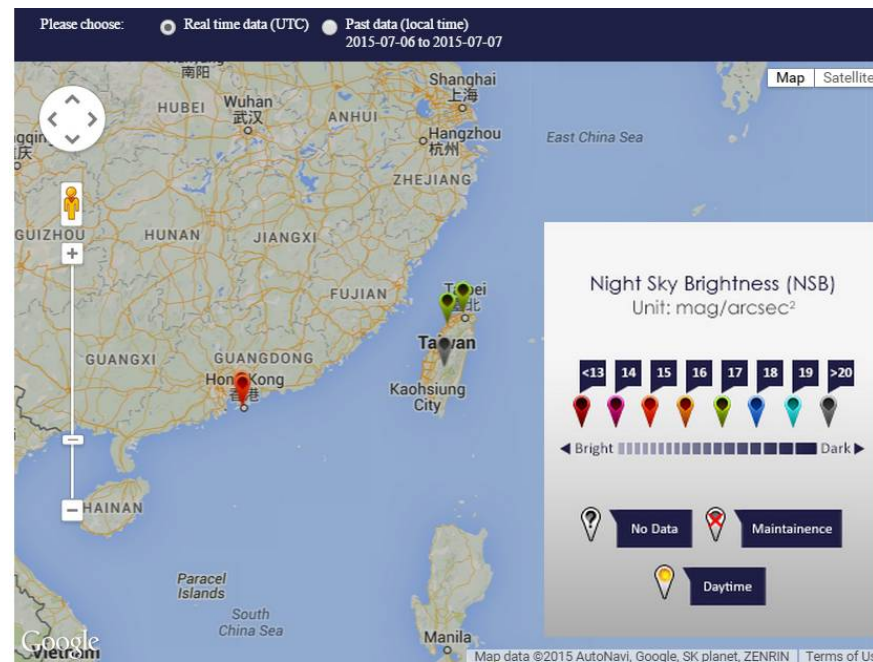

대전시민천문대
Daejeon Astronomical Observatory

영양군 자연생태공원관리사업소
반딧불이담당 박제훈
Yeongyang Firefly Astronomical Observatory

Public Interface of GaN-MN

http://globeatnight-network.org/

- A global light pollution map based on Google Map platform:
  - ➢ Real-time data displayed for locations currently at night time
  - ➢ Median value of NSB taken during the previous night for locations currently at day time

Early performance of GaN-MN – nightly trends (preliminary results)
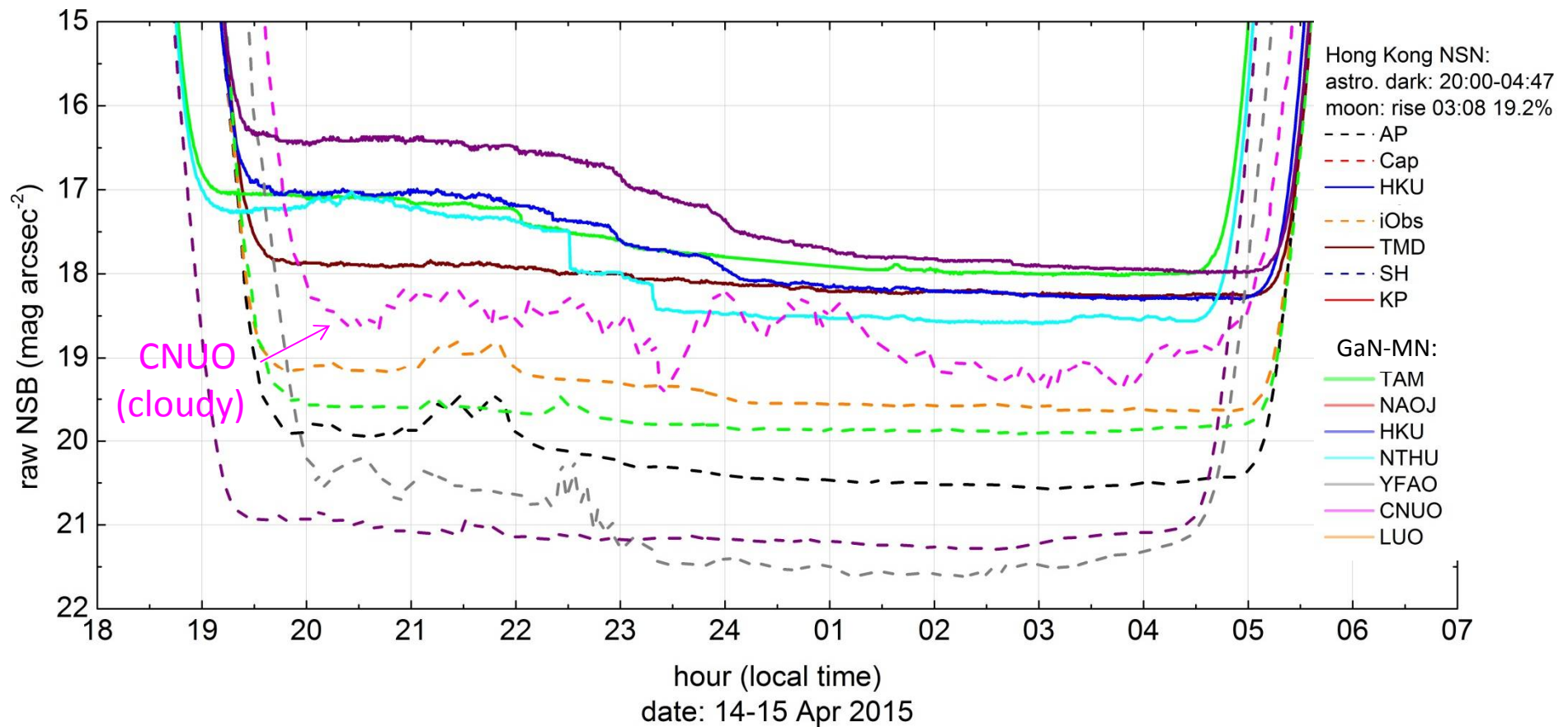
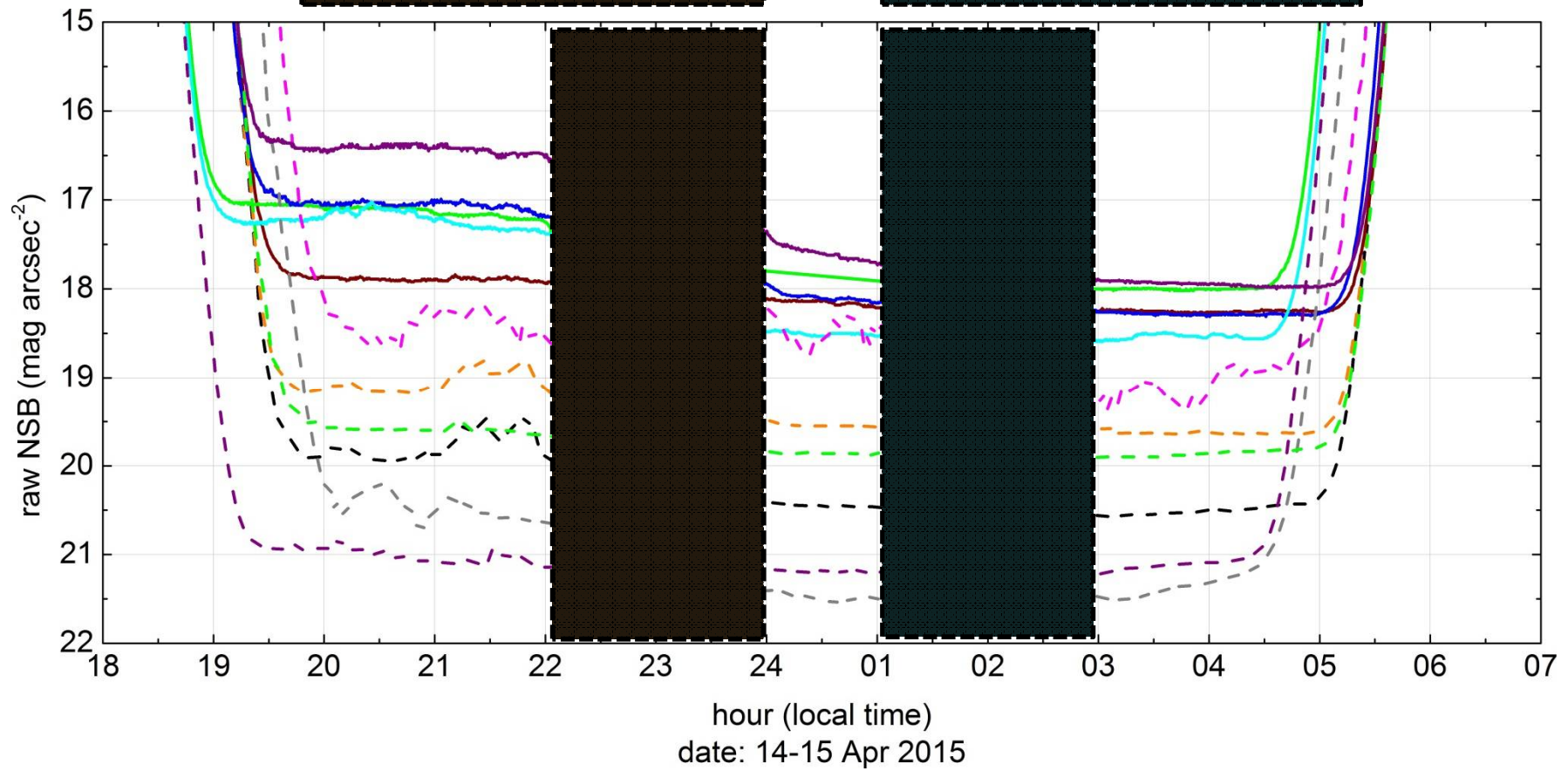# Early performance of GaN-MN – nightly trends (preliminary results)
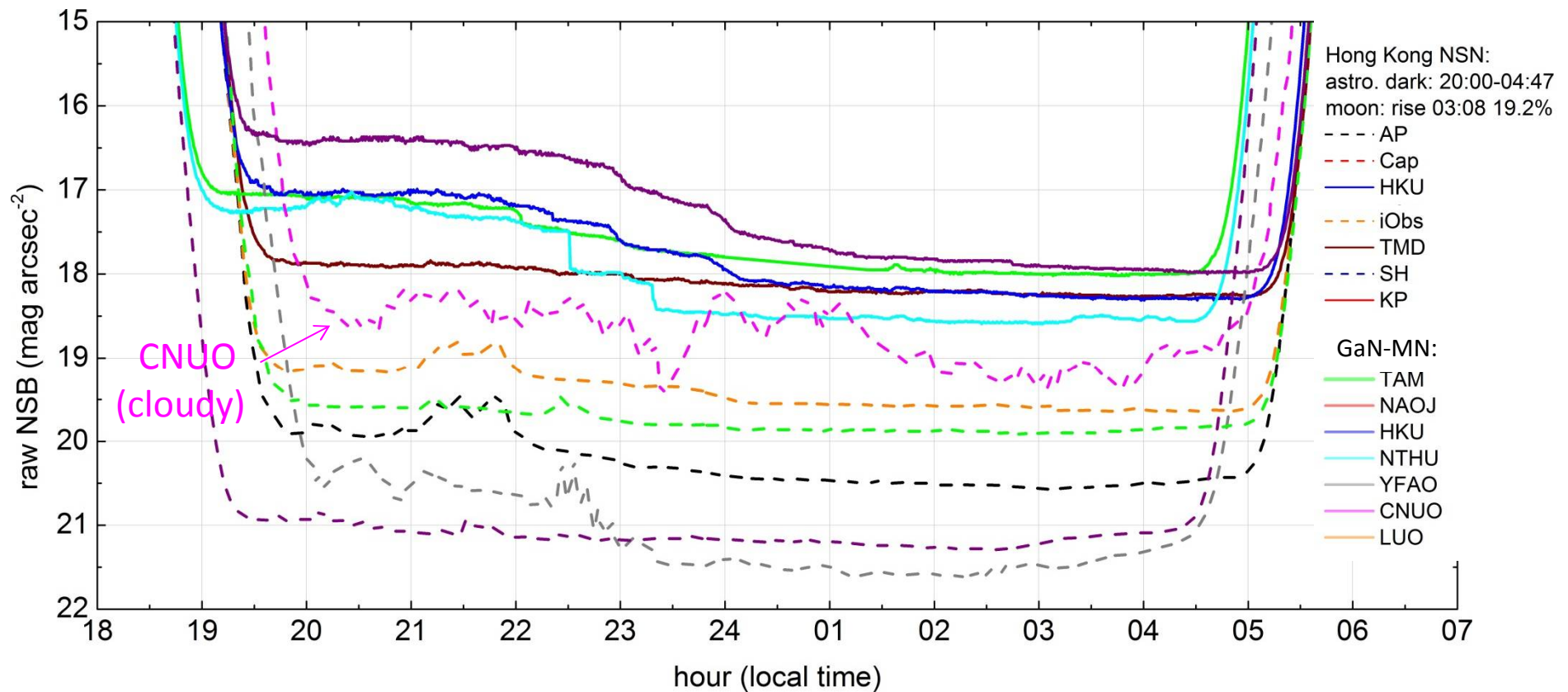
Observations:
The sky is generally darker in late night.
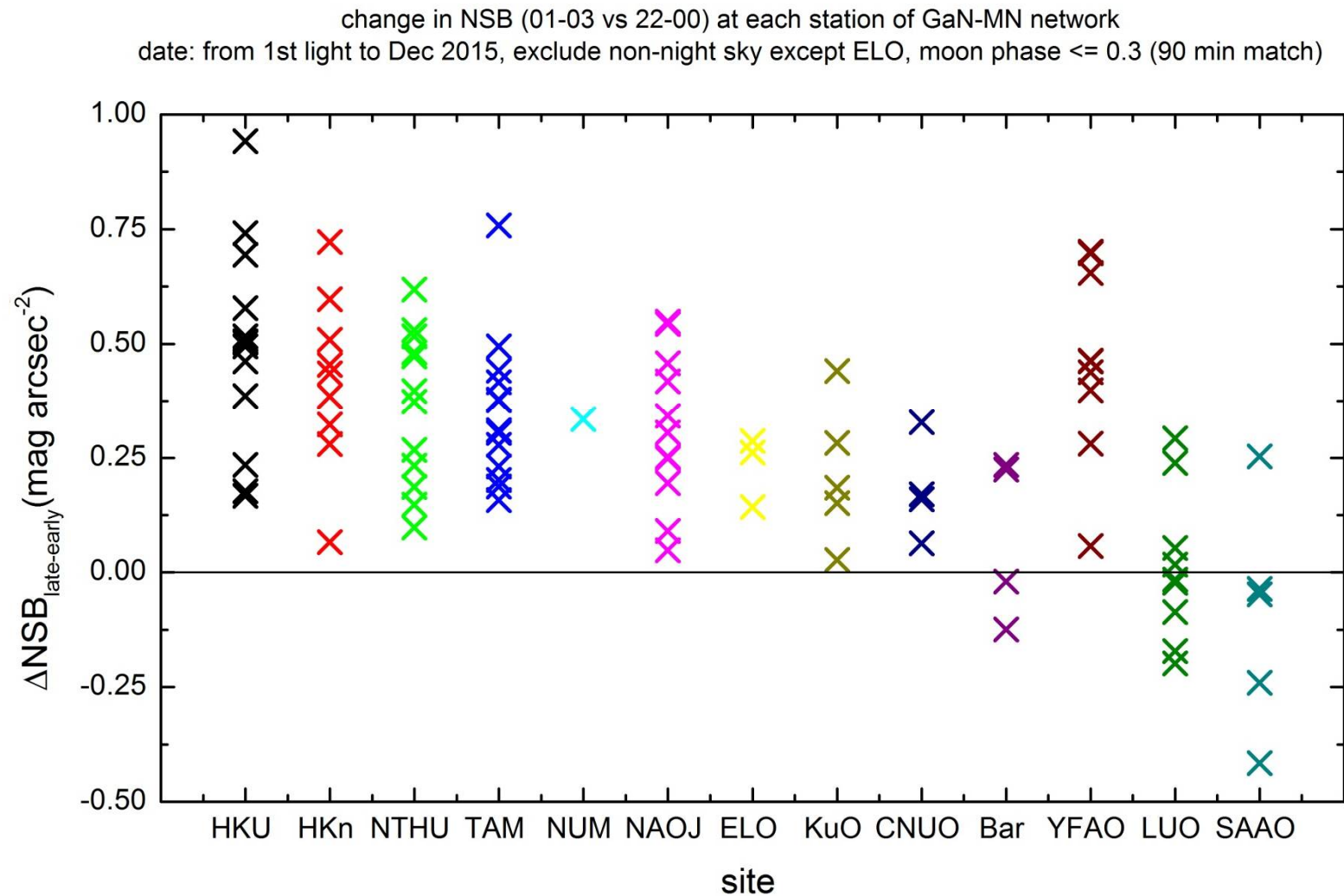Urban stations are brighter than suburban and rural stations.

$$\Delta NSB_{late\text{-}early} = NSB_{late} - NSB_{early}$$

Average NSB between
22:00-24:00 = NSB_{early}

Average NSB between
01:00-03:00 = NSB_{late}

raw NSB (mag arcsec^{-2})

hour (local time)
date: 14-15 Apr 2015

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

change in NSB (01-03 vs 22-00) at each station of GaN-MN network
date: from 1st light to Dec 2015, exclude non-night sky except ELO, moon phase <= 0.3 (90 min match)
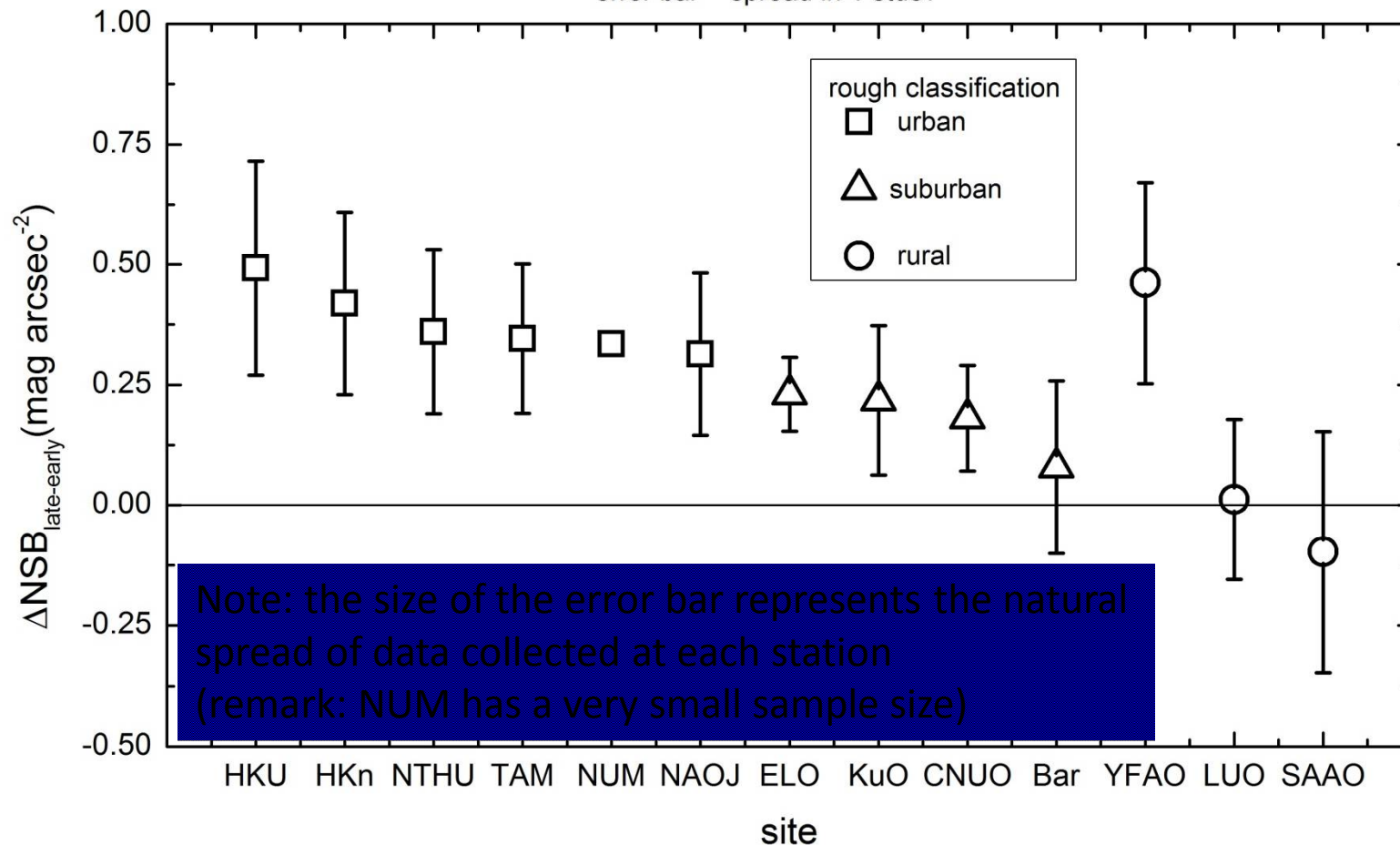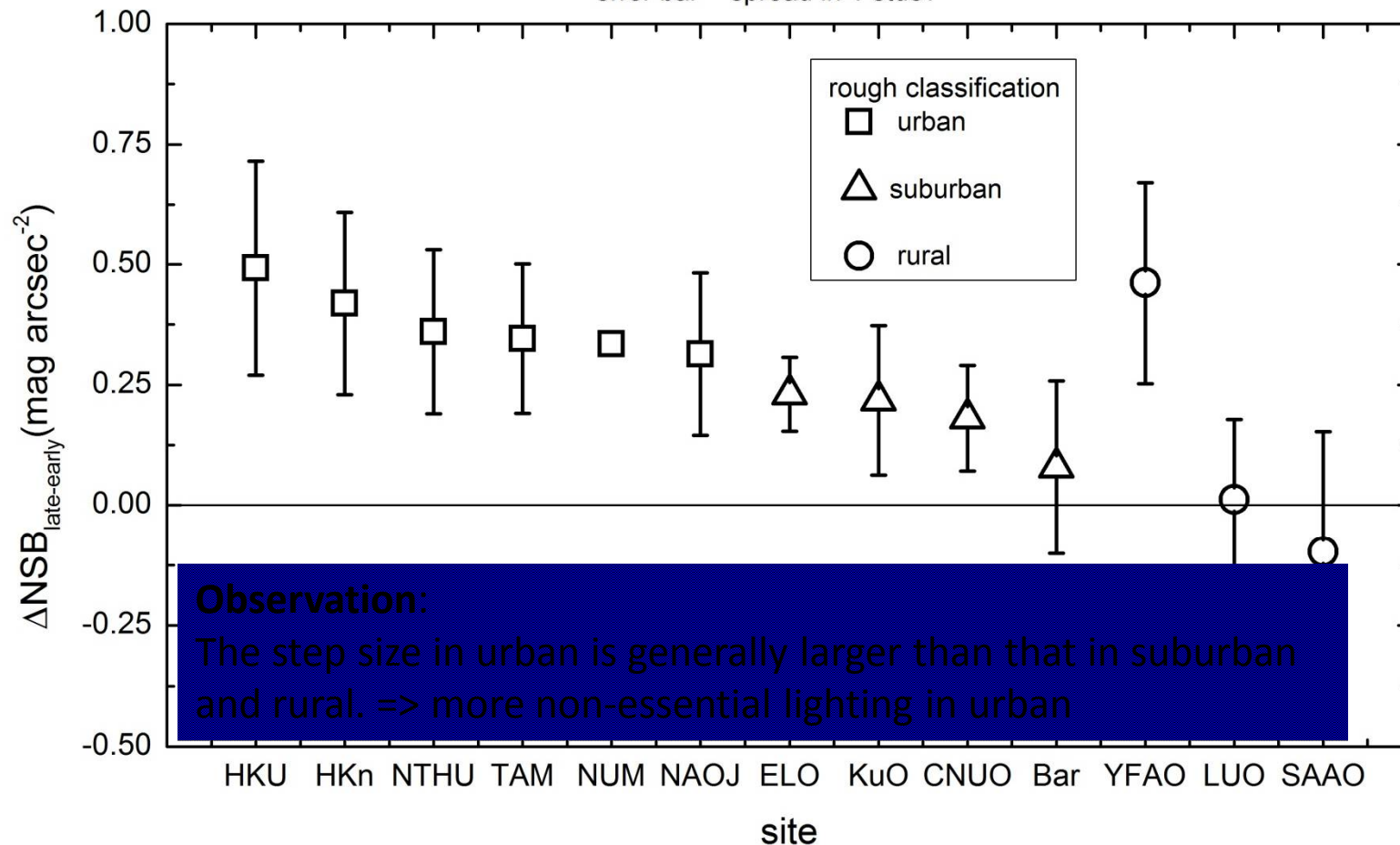
Early performance of GaN-MN – nightly trends (preliminary results)

change in NSB (01-03 vs 22-00, monthly average) at each station of GaN-MN network
date: from 1st light to Dec 2015, exclude non-night sky except ELO, moon phase <= 0.3 (90 min match)
error bar = spread in 1 stdev

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

change in NSB (01-03 vs 22-00, monthly average) at each station of GaN-MN network
date: from 1st light to Dec 2015, exclude non-night sky except ELO, moon phase <= 0.3 (90 min match)
error bar = spread in 1 stdev

Observation:
The step size in urban is generally larger than that in suburban and rural. => more non-essential lighting in urban

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

change in NSB (01-03 vs 22-00, monthly average) at each station of GaN-MN network
date: from 1st light to Dec 2015, exclude non-night sky except ELO, moon phase <= 0.3 (90 min match)
error bar = spread in 1 stdev

Observation:
YFAO has an unexpectedly large step. Specific use of lighting pattern?
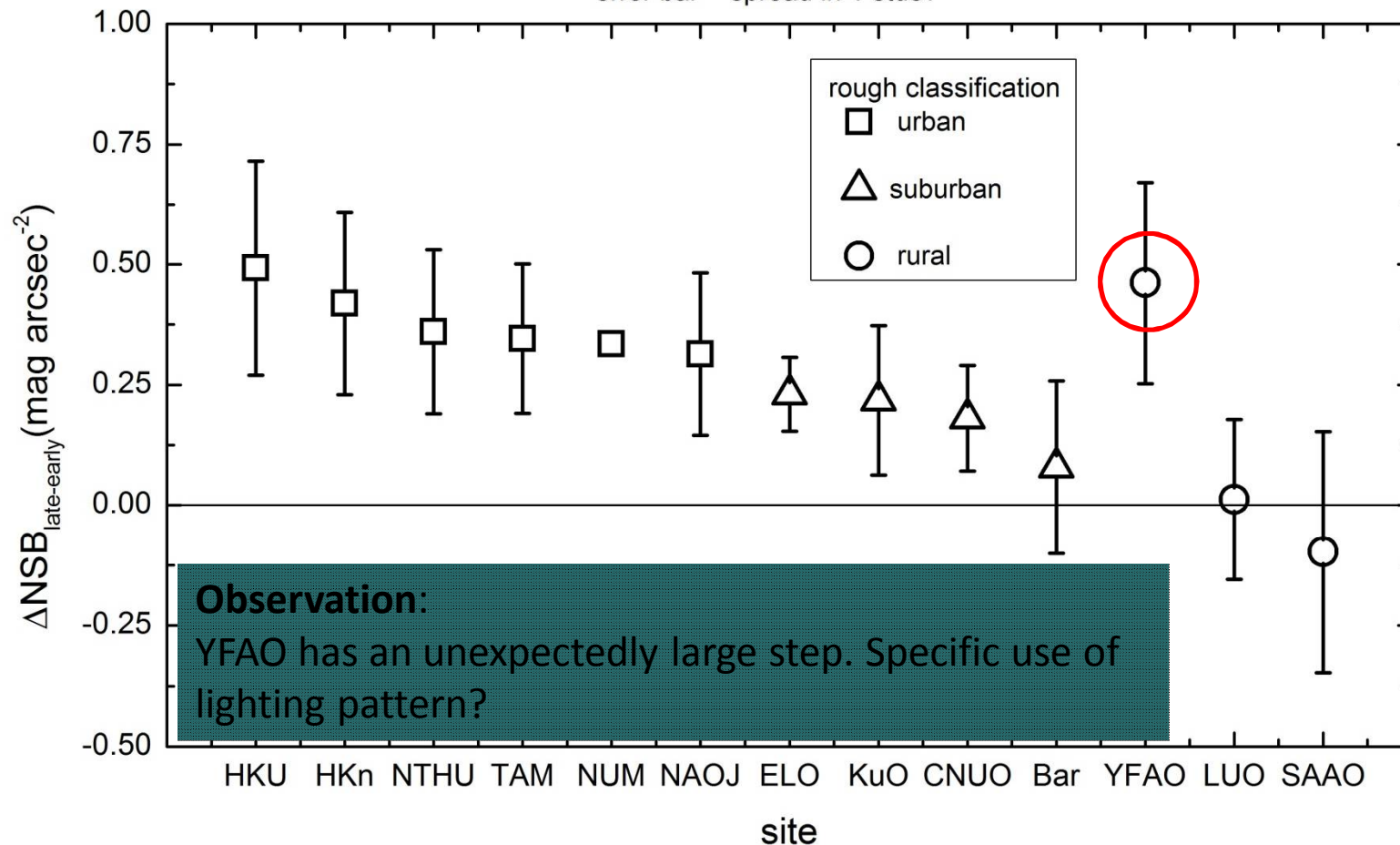
The GaN-MN night sky brightness database

- 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
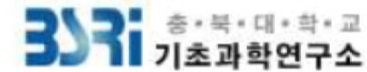
International Workshop
on Night Sky Brightness Measurements

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

Thank you!

For more information on the GaN-MN,

1) Join the workshop!
2) Visit: http://globeatnight-network.org/
3) Email us at: globeatnight.network@gmail.com or
   gan-mn@qq.com