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

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Challenge

To measure the extent of light pollution over large area
1. Measuring Light Up

- **Remote sensing** (DMSP-OLS, VIIRS-DNB, ISS, etc)
  - Upwelling light emitted directly from the light sources and light reflected off the Earth’s surface.
  - Challenging calibration issues but can be overcome
  - Large spatial coverage (city → regional → global)
  - Low temporal sampling (each location normally has one chance of overpass within an evening; DMSP: 19:30, VIIRS: 01:30)

F. Falchi et al. 2016
C.C.M. Kyba et. al. 2015
2. Measuring skyglow

- **Limiting magnitude** (e.g. Globe at Night, since 2006)
  - Citizen science project to report conditions of the night sky
  - Large geographical (115 countries) & temporal coverages with low cost
  - Uncertain data quality within the data set (±1.2 mag, due to various observing experience & mistakes made during data reporting, Kyba 2013)

Image credit: Globe at Night
2. Measuring skyglow

• Measuring Night Sky Brightness (NSB)
  – Through mobile phone apps or specialized light sensing meters
  – Mobile phone citizen science (e.g. Dark Sky Meter): good geographical but unsteady temporal coverage
  – Dedicated measuring devices: for SQM, limited temporal and geographical coverage
  – With ethernet or data-logger versions of SQM, we can set high sampling rate also good temporal coverage
  – Temporal coverage provides a direct linkage with the pattern of light usage.
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

• 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)

• 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:
  – Zenith night sky brightness observation
  – 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

Image credit: Taipei Astronomical Museum
The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

• GaN-MN currently (June 2017) has:
  – 23 stations operating in 9 countries/regions in 3 continents
  – Over 30 million individual measurements had been collected
The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Current stations (23 in total):
  - Germany 1
  - Hungary 2
  - Mongolia 1
  - South Africa 1
Data sharing:

1. Public interface of GaN-MN (embedded in Google map)
   http://globeatnight-network.org/

- Location currently at night: instantaneous real-time data
- Location currently during day-time: median value of NSB taken during previous night
Data sharing:
2. Real-time database

• All NSB data collected from GaN-MN stations fed to a MySQL database automatically and instantaneously

• **Full sharing of real-time data from all stations** among participating stations

• Participants access database through a user-friendly web-based interface

• Database allows for studies of temporal and geographical variations of light pollution and their correlations with various natural and artificial factors
Data sharing:

3. Archival database (accessed through Globe at Night page)
https://www.globeatnight.org/gan-mn.php
(Home page > Maps & Data)

- New archival file around once per month
- Raw data only limited quality check. Please contact us for details.
Raw data taken over one month at one station between 18:30 – 00:00

**Astronomical**
- Galaxy, starlight, moonlight, sunlight, etc

**Meteorological / Atmospheric**
- Cloud, rain, air pollution, etc

**Anthropological**
- Public and private lighting, different colors, different angles, LED, etc
Data Selection

• For this particular analysis, focus on how and how much artificial lighting can affect the observed NSB (urban skyglow)

• Data excluded due to:
  • Sun (twilight)
  • Moon
  • artificial activities (such as observatory functions, etc)

• Data NOT excluded:
  • star/planetary light, Milky Way galaxy
  • rain
  • cloud
Monthly sample size (bars) and average NSB (lines) of a GaN-MN urban station (Hong Kong)

- Early evening brighter than late evening (lighting usage)
- Seasonal fluctuations (variations of cloud amount)
Monthly sample size (bars) and average NSB (lines) of a GaN-MN rural station (central mountain Taiwan)

Much darker NSB (land utilization and population density)
Similar early and late NSB (minimal lighting usage)
Define parameter

$$\Delta \text{NSB}_{\text{late-early}} = \text{NSB}_{\text{late}} - \text{NSB}_{\text{early}}$$

Average NSB observed after 01:00 local time = \(\text{NSB}_{\text{late}}\)

Average NSB observed before 22:00 local time = \(\text{NSB}_{\text{early}}\)

Positive \(\Delta \text{NSB}_{\text{late-early}}\) \(\rightarrow\) darker after mid-night

Negative \(\Delta \text{NSB}_{\text{late-early}}\) \(\rightarrow\) brighter after mid-night

Similar to “t-Grad” introduced by Thomas Posch
How much the early evening is brighter than that of late evening

Larger $\Delta \text{NSB}_\text{late-early}$ in urban locations due to more sources of light pollution in urban
Average $\Delta \text{NSB}_{\text{late-early}}$ vs $\text{NSB}_{\text{early}}$ for each GaN-MN station

In general, when more light is used (low $\text{NSB}_{\text{early}}$), more light can be turned off (high $\Delta \text{NSB}_{\text{late-early}}$)

early: before local 22:00  
late: after local 01:00  
symbol color follow relative sample size

- light shield applied due to dense ambient lighting
- different pointing & housing

early - late scatter plot overlaying all stations (2018-2020)
Average $\Delta \text{NSB}_{\text{late-early}}$ vs $\text{NSB}_{\text{early}}$ for each GaN-MN station

Message to the relevant stakeholders: How to reduce $\Delta \text{NSB}_{\text{late-early}}$ at a particular location?
Average nightly variation of NSB for each station

- “Jellyfish scotograph” (introduced by Thomas Posch)
- Huge range of NSB among stations
- Different latitudes of stations lead to different sampling time (astro. dark durations)
- Each curve is unique: Depicts the outdoor lighting usage at that particular location
Average nightly variation of NSB for each station

- Most show a **gradual** decrease of sky brightness throughout the evening
- Suggest a decreasing amount of light pollution gradually due to reduction in light usage
Some locations reveal one or multiple **sharp drops** ("curfews") in sky brightness throughout the evening.

- Lighting pattern identified: massive switch-off of lighting at specific times every night.
- Some locations have **roughly steady** level of sky brightness throughout the evening

- Two types identified:
  1. minimal ambient lighting
  2. special lighting usages
The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

• Easy to join in the effort

• All you need are:

  – A working SQM-LE with the standard Housing from Unihedron
  – Power supply and internet connection

• Benefits:

  – Present your results real-time to the world
  – Let’s fight light pollution together!
Thank you!

For more information on the GaN-MN or willing to join,


2) Email me (Chu Wing SO) at: [globeatnight.network@gmail.com](mailto:globeatnight.network@gmail.com) or [gan-mn@qq.com](mailto:gan-mn@qq.com)