Night Sky Brightness Measurements: Review and Prospects

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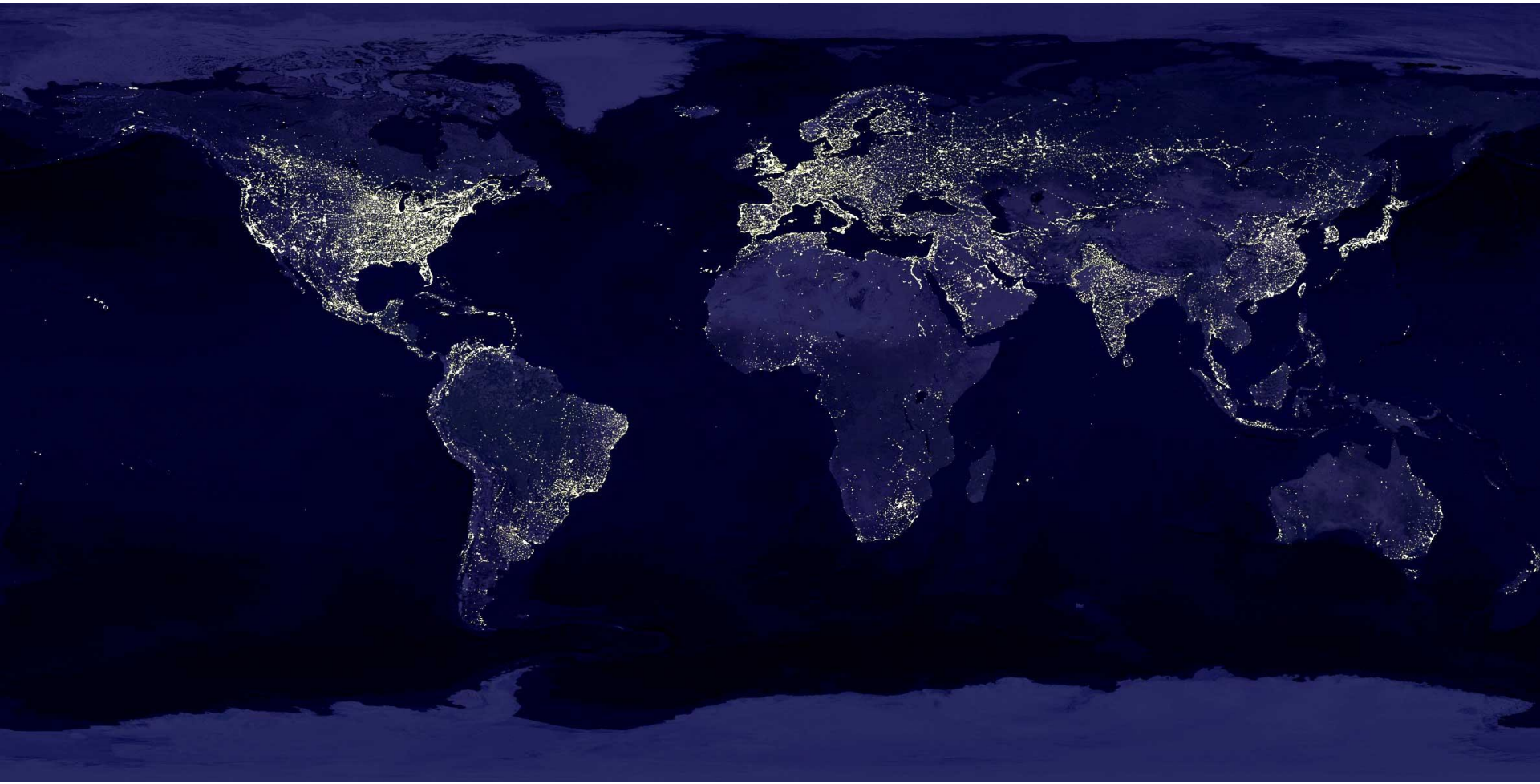
The globe at night



Measurement of Light Pollution

- Light Pollution: environmental degradation due to artificial lighting
- Effects of light pollution can be
  - "Local" (*light nuisance, light trespass*), often assessed from effects on ecological systems and on humans' health; Measured by luxmeters, etc
  - "Extended" (*sky glow*), assessed from atmospheric and astronomical effects.
- Night sky brightness measurements include BOTH artificial sky-glow and natural components (airglow, zodiacal/star/Galactic light, etc)

Night Sky Brightness (NSB) Measurements

- Astronomical photometry
- Wide-field photometry
- Remote sensing
- Citizen science
- Dedicated NSB devices
- Night sky spectroscopy
- Others
  - Visual Photometer
  - Comets, …

Astronomical photometry

- Photometric measurements of the night sky using optical telescope
- Equipment:
  - CCD camera (or photomultiplier tubes, PMT)
  - Telescope
  - Filters
- Advantages:
  - Photometric accuracy is very high (error $\leq \pm 0.02$ mag arcsec^{-2})
  - Multiple bands measurement
- Disadvantages:
  - Highest cost (personnel, equipment)
  - Low geographical (at the observatory) & temporal (relatively few observations per nights) coverages

Astronomical photometry: Patat (2008)

Patat, F. 2008, Astronomy & Astrophysics, 481, 575

- Very Large Telescope (VLT), La Silla Paranal Observatory, Chile
- Sensor: FOcal Reducer/low Dispersion Spectrograph (FORS1)
- Filters: photometric broadband Johnson-Cousins UBVRI
- Period: year 2000-2006
- Data collection: about 10,000 images from more than 650 separated nights

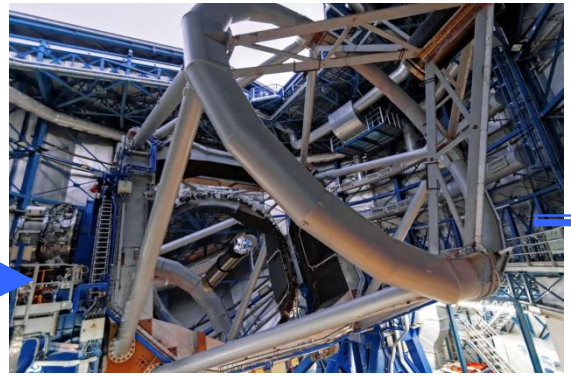
Photo credit: ESO

Methodology

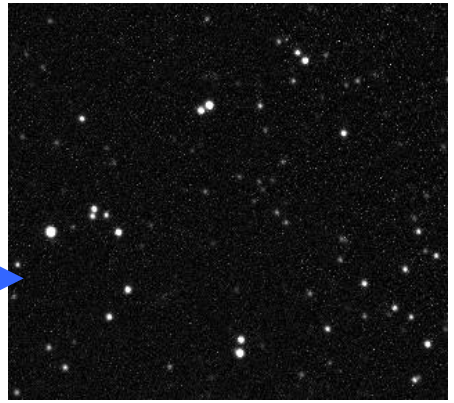
More details at Patat, F. 2003a, Astronomy & Astrophysics, 400, 1183

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

observatory



telescope + sensor



imaging on object & standard star fields

data pre-processing (bias, dark & flat-field)

aperture photometry

color transformation coefficients

extract NSB (Patat 2003b)

color transformation equations

calibrated NSB

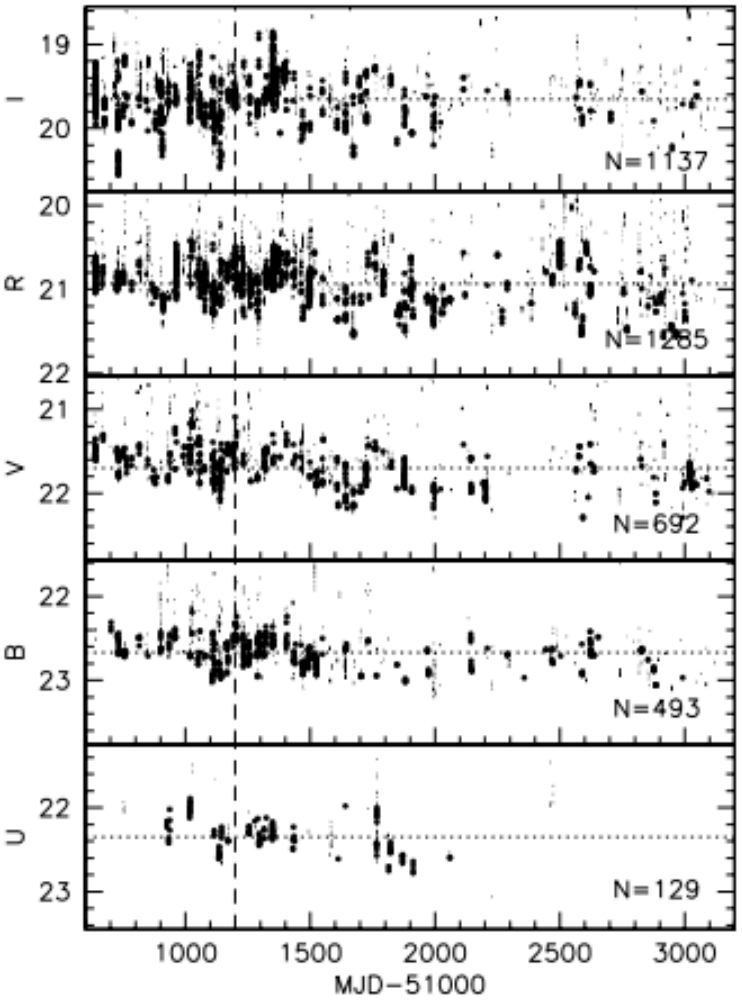
standard zenith NSB

Result highlights

Filter	Sky Br.	σ	Min	Max	$N_{\rm dark}$	$\Delta m_{\rm ZL}$	$N_{\rm tot}$
U	22.35	0.19	21.89	22.78	129	0.20	264
B	22.67	0.16	22.19	23.02	493	0.28	1400
V	21.71	0.24	21.02	22.30	692	0.20	1836
R	20.93	0.24	20.42	21.56	1285	0.16	3931
I	19.65	0.28	18.85	20.56	1137	0.07	3001
Total					3736		10 432

Note: Values are expressed in mag arcsec^{-2}. Columns 3 to 8 show the rms deviation, minimum and maximum brightness, number of dark-time data points, expected average contribution from the zodiacal light, and total number of data points.

- *UBVRI* NSB correlated with solar activity.
- *V*, *R*, and *I* results show a 6-month oscillation pattern



Zenith-corrected dark time NSB measured at Paranal

Wide-field photometry

- Photometric measurements of the night sky using wide-field light correctors
- Equipment: all-sky camera, wide-field lens (e.g., fish-eye lens), etc
- Advantages:
  - Relatively low cost (compare with traditional photometry)
  - Can be portable, i.e., larger geographic coverage
  - Collect information on directional distribution of light pollution
- Disadvantages:
  - Absolute calibration over the entire frame and over time can be a challenge

Wide-field photometry: Duriscoe et. al. (2007)

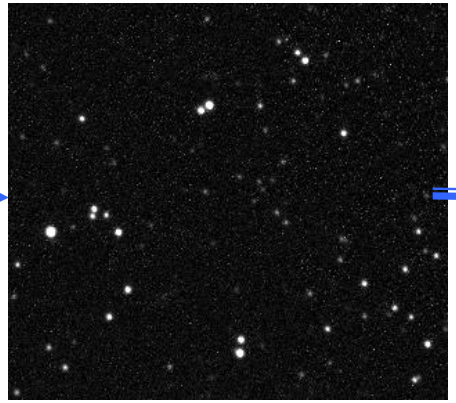
Duriscoe et al. 2007, Publications of the Astronomical Society of the Pacific, 119, 192

- Location: over 80 locations throughout the US
- Lens: Nikon 35 mm f/1.4, Nikon 50 mm f/1.8
- Mount: Celestron NexStar
- Sensors: Apogee AP260EP, Finger Lakes Instruments MaxCam CM9, SBIG STL 1001E, Finger Lakes Instruments IMG 1001E
- Filter: Custom Scientific Bessell V
- Period: 2001+
- Data collection: over 300 all-sky observations

Methodology

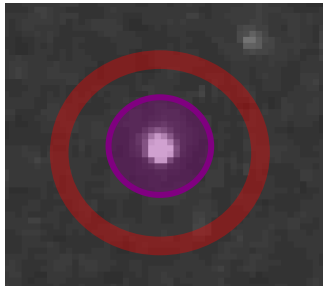
Flowchart:

telescope setup

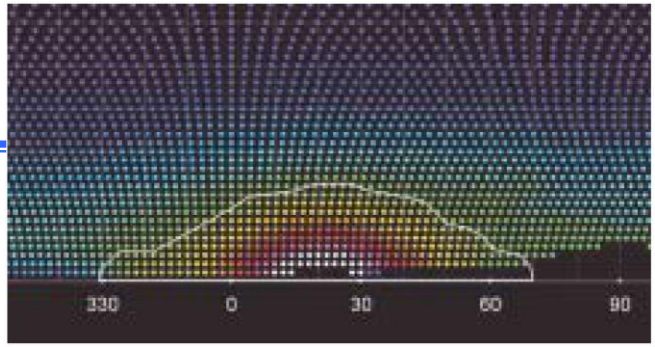


sky imaging &
standard star fields

data pre-processing
(bias, dark & flat-field)

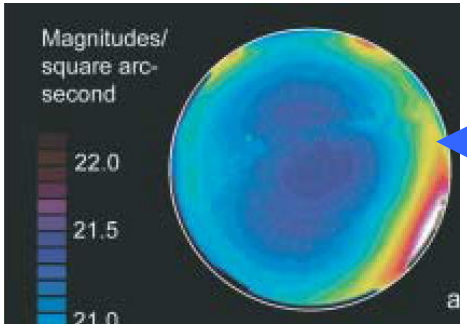


aperture
photometry



extract NSB

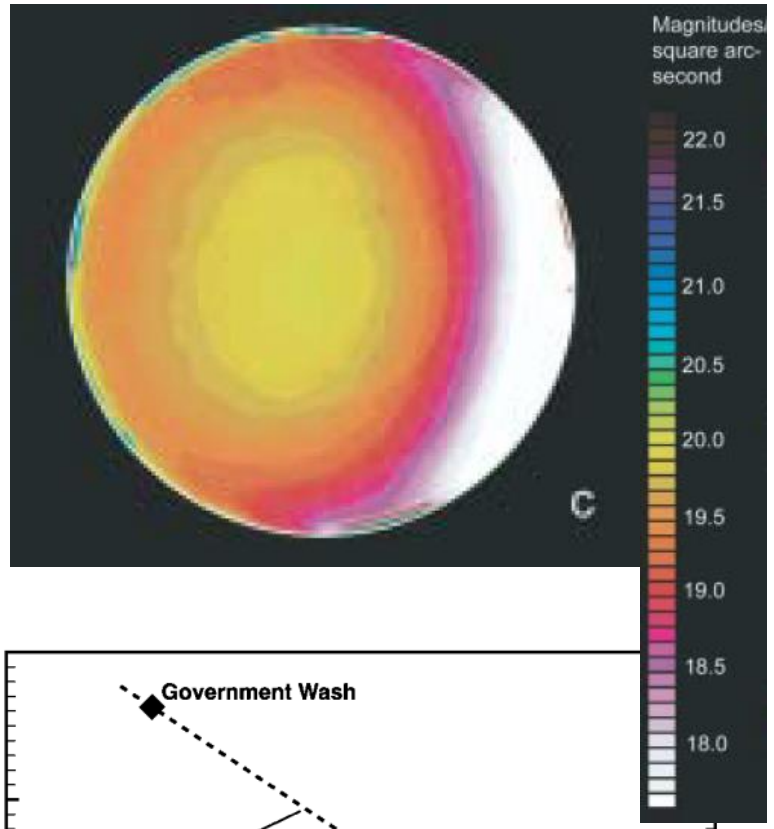
(sample points evenly every 2deg)

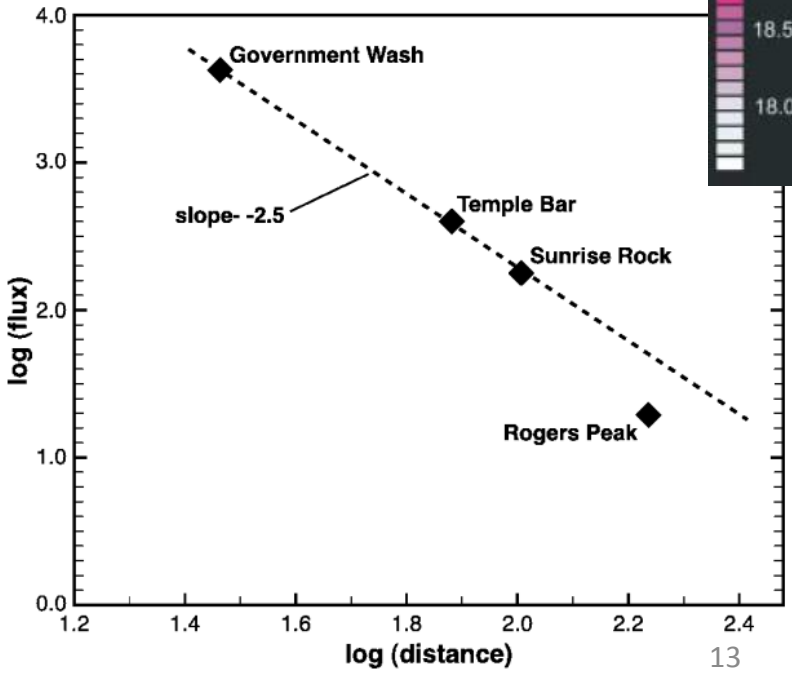


mosaic all-sky data

Result highlights

- Light domes identified.
- Total light from the city sky glow higher than any permanent celestial objects except the Moon.
- City effects detected up to 100 - 170 km from the city center





Natural sky brightness Model

Duriscoe, 2013, Publications of the Astronomical Society of the Pacific, 125, 1370

- Moonless natural sky *V*-band brightness model
- Considered: zodiacal light, airglow, integrated starlight, diffuse galactic light
- Deduce the artificial component from all sky images

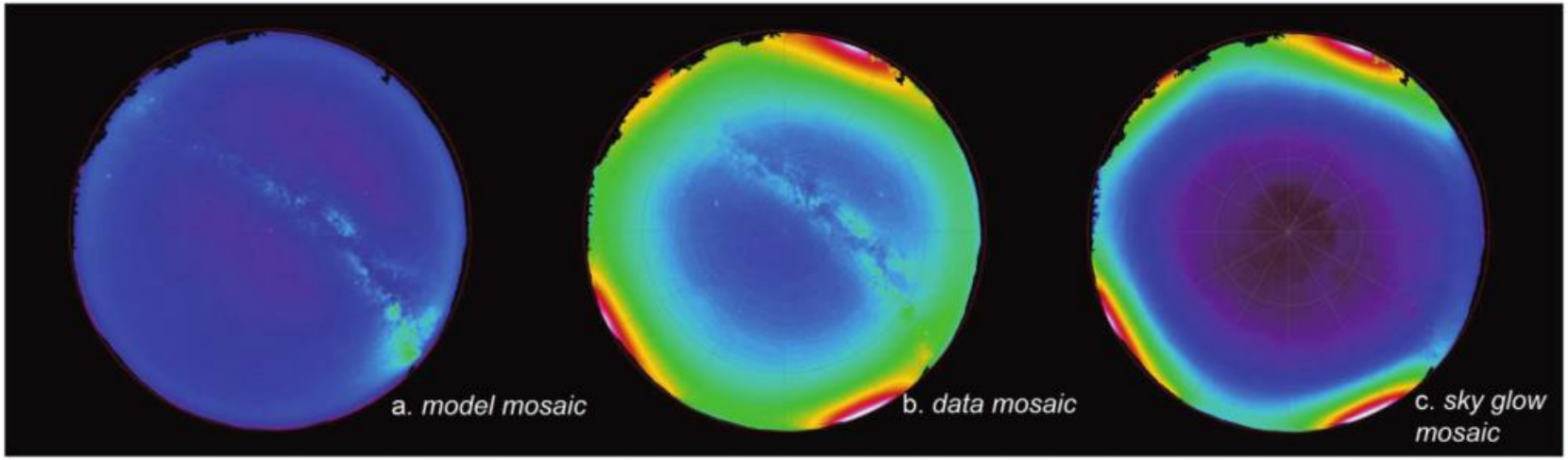


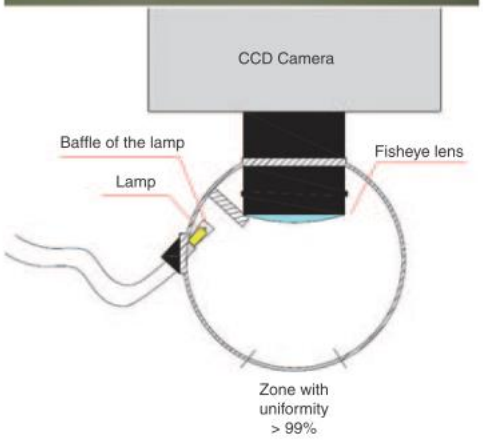
FIG. 12.—Sky brightness at Bandelier National Monument, New Mexico. From this site the light domes of several cities around the horizon are evident, as well as significant anthropogenic sky glow at the zenith (*c*). The airglow component in the model (*a*) is arbitrarily set at a moderate level.

Wide-field photometry: Rabaza (2014)

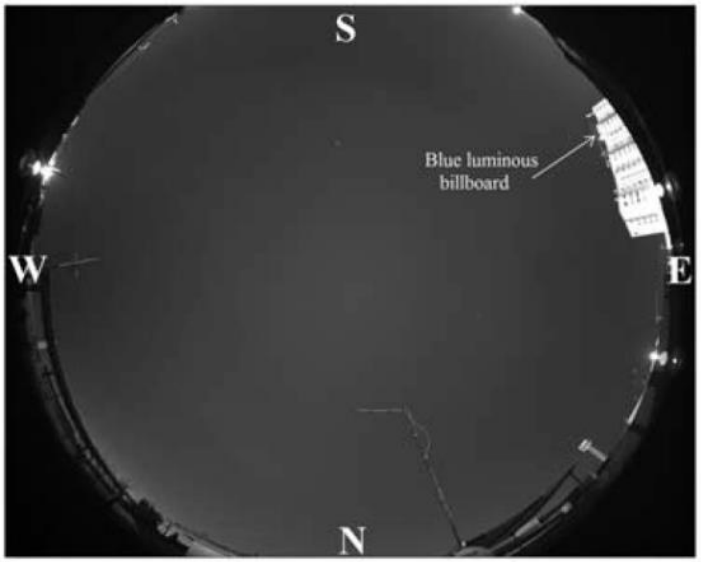
Rabaza, D. 2014, Lighting Research & Technology, 46, 5

- Location: Spain
- Lens: AF DX Fisheye-Nikon 10.5 mm f/2.8 G ED (180 deg FOV)
- Sensor: SBIG STL-11000 M
- Filters: narrow-band interference filters centered at 438.2, 527.8, 555.0, 568.4, 577.8, 598.3 and 618.0 nm
- Period: ?
- Data collection: ?
- Calibration: integrating sphere

Methodology



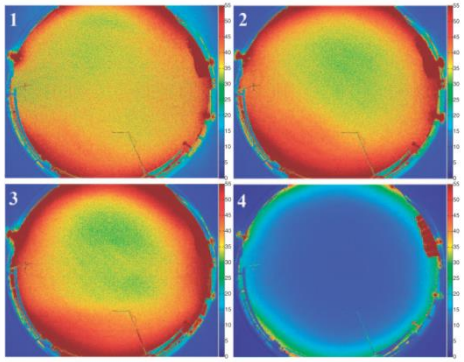
setup



data collection

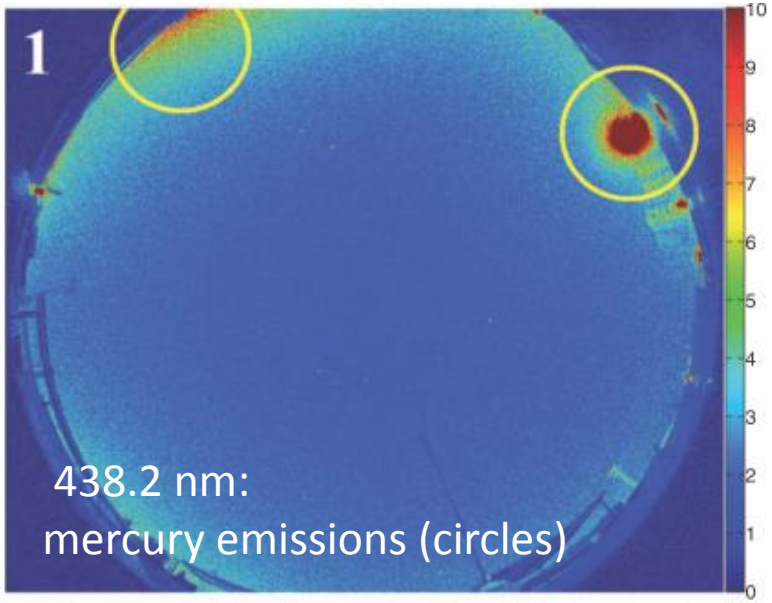
calibration (integrating sphere,
synthetic flat field)

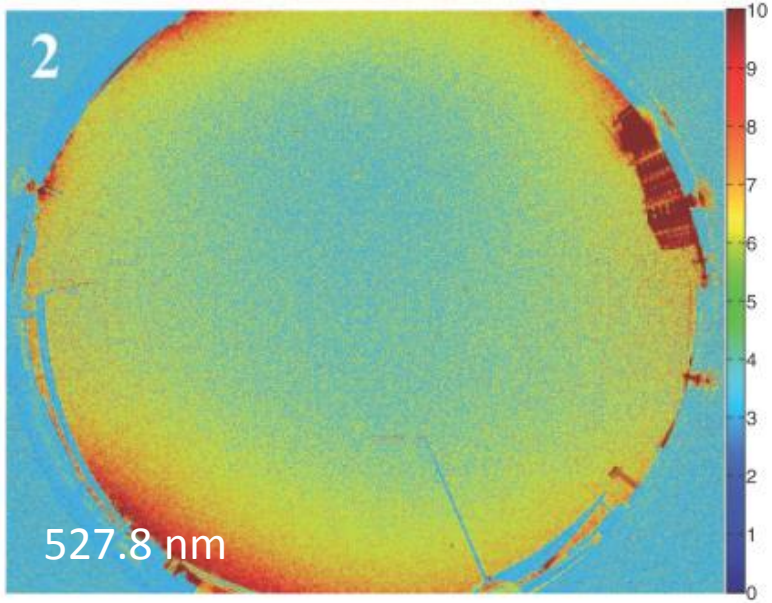
data processing



Result highlights

- Monochromatic luminance and radiance of the sky background measured
- Color information may reveal the kind of lamps that emitted the main components of the obtrusive light detected





Remote sensing

- Data: night-time remote-sensed data such as:
  - Operational Linescan System, Defense Meteorological Satellite System (OLD-DMSP)
  - Day-Night Band, Visible Infrared Imaging Radiometer Suite (DNB-VIIRS, Suomi National Polar-orbiting Partnership)
  - International Space Station (ISS)
  - aerial photos
- Advantages:
  - Large geographic coverage (up to global scale)
- Disadvantages:
  - Low temporal coverage
  - Low geographic resolution for sub-city analysis (DMSP)
  - Single band of observation (except ISS)
  - Absolute calibration over the large spatial coverage and over time

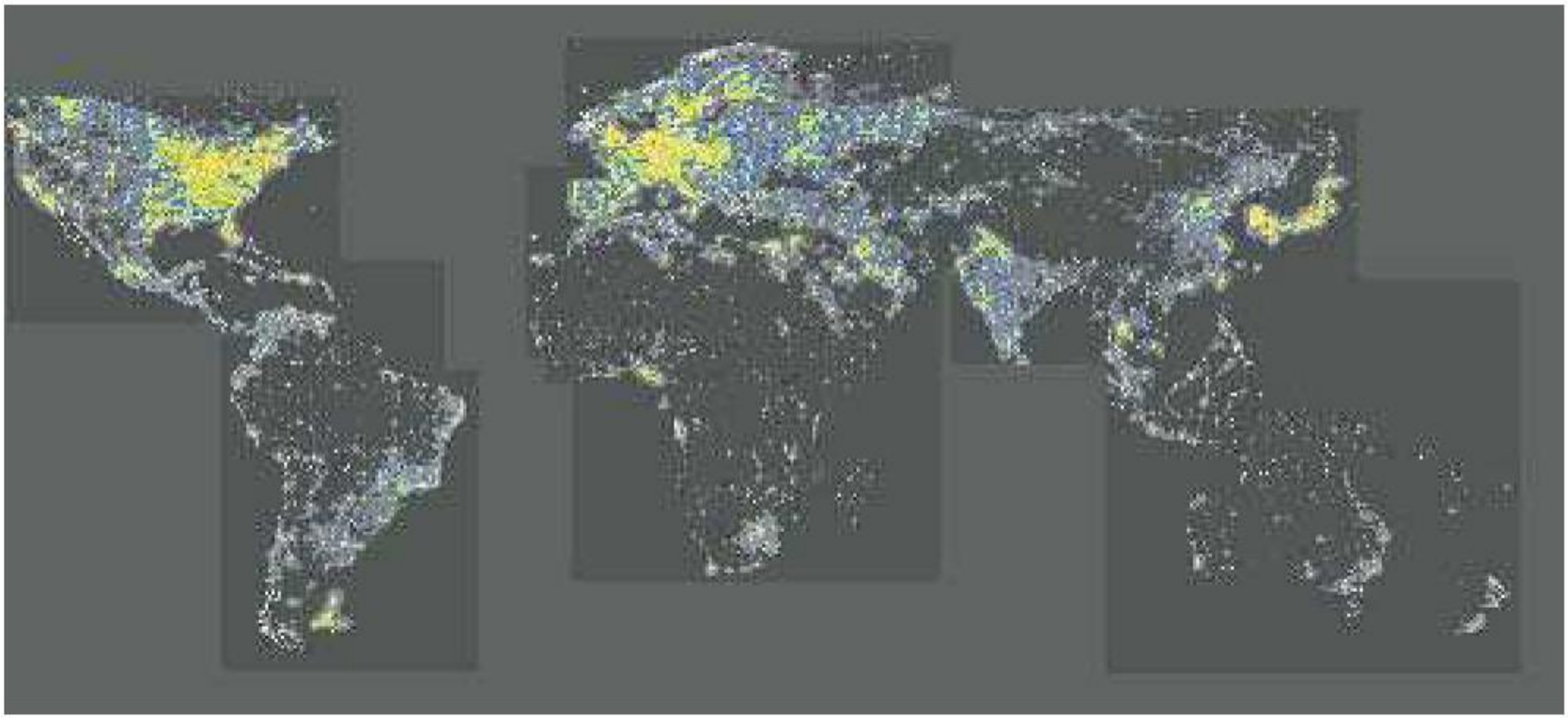
Remote Sensing: Cinzano et. al. (2001)

Cinzano, P. et. al. 2001, Monthly Notices of the Royal Astronomical Society, 328, 689

- Data: cloud-free composite of OLD-DMSP
- Scale: worldwide
- Sampled period: 28 nights during 1996-1997
- Band: converted to photometric astronomical *V* band at zenith
- Calibration: radiance data based on a pre-flight irradiance calibration of the OLS PMT
- Light propagation model:
  - Rayleigh scattering by molecules, Mie scattering by aerosols, atmospheric extinction along light paths and Earth curvature

Result highlights

- The World Atlas of the Sea Level Artificial Night Sky Brightness



Result highlights

- Light pollution is a global-scale problem affecting nearly every country of the world
  - the night sky appears more seriously endangered than commonly believed
- Large numbers of people have lost their dark sky
  - For more than 1/4 of the world population, the sky brightness is even greater than that measured on nights close to full moon in the best astronomical sites
- Sky quality near astronomical observatories severely degraded in less than 20 years

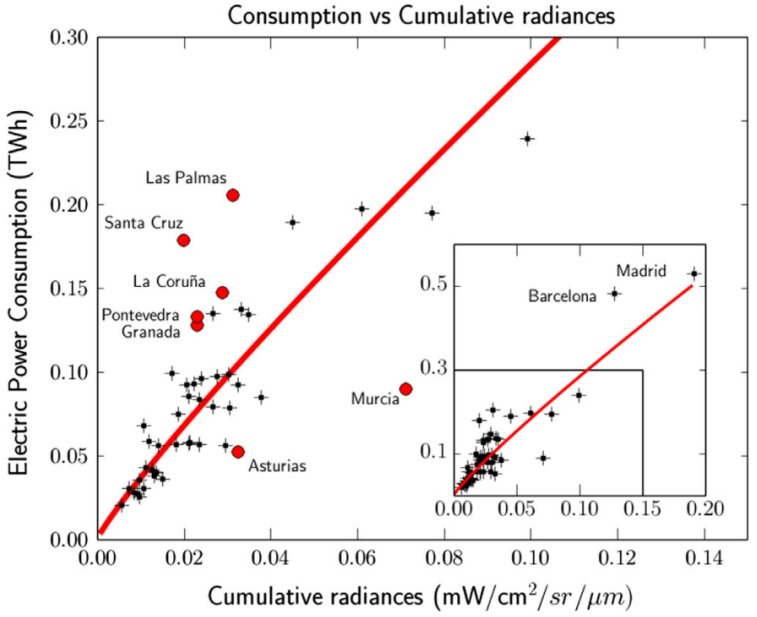
Remote Sensing: A. Sánchez de Miguel et. al. (2014)

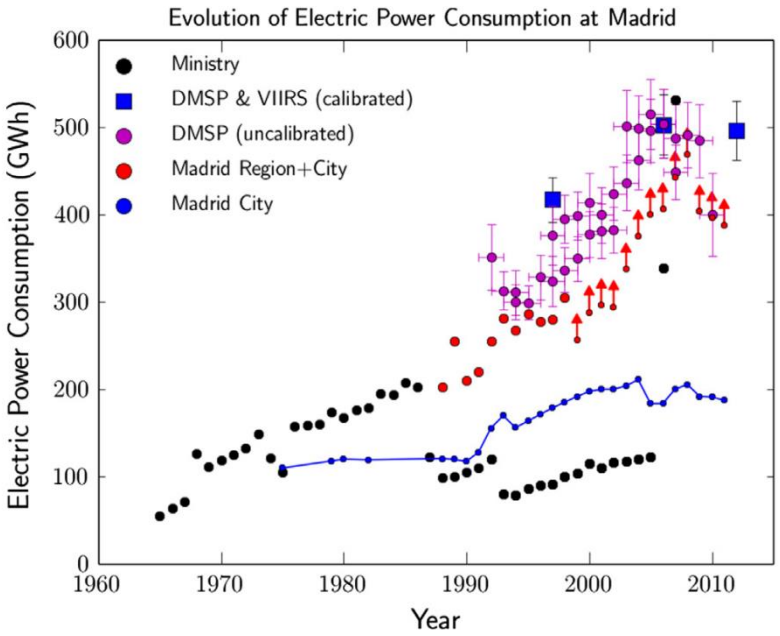
A. Sánchez de Miguel et. al. 2014, Journal of Quantitative Spectroscopy & Radiative Transfer , 139, 109

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

Result highlights

- Strong correlation between the radiance and energy consumption
- Derived the electricity consumption for street lighting in Spain from 1992 to 2010
  - doubled in the last 18 years in most provinces

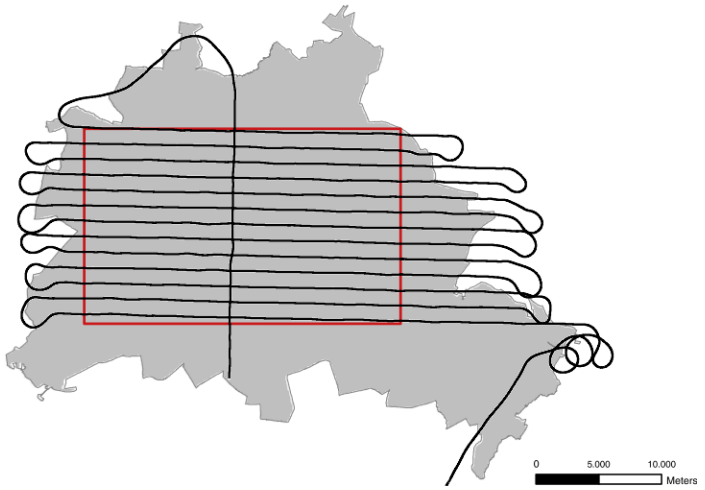




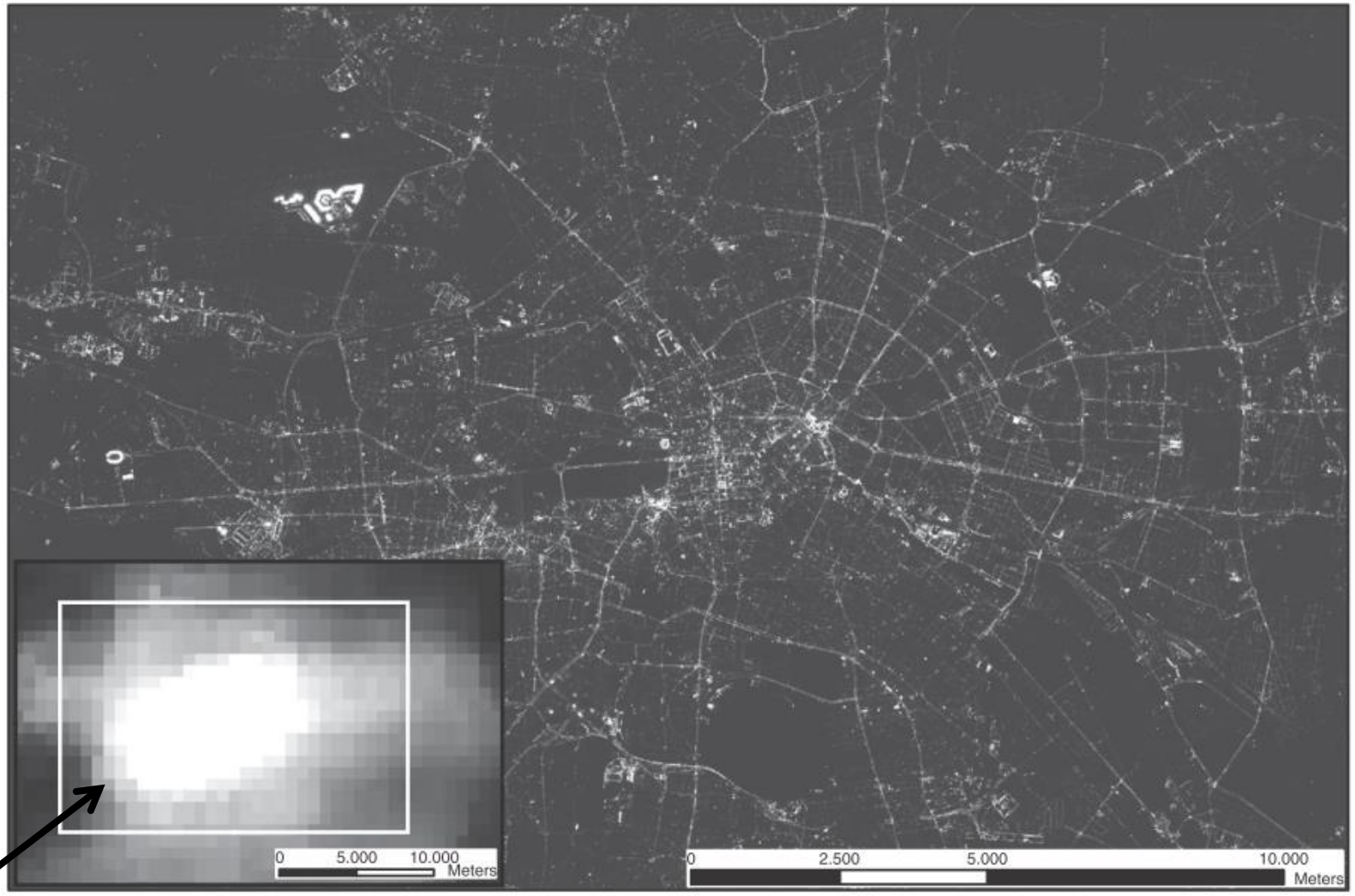
Remote Sensing: Kuechly et. al. (2012)

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

- Data: mosaic image from aerial(3000 m) photography
- Spatial resolution: 1 m
- Coverage: Berlin, Germany
- Sampled period: single flight during 20:40 - 23:23 local time (UT+2) 11 September 2010
- Sensor: Finger Lakes Instruments camera (interline transfer CCD)
- Lens: Sigma 24 mm F1.8 DG
- Filters: Luminance, Red, Green, Blue

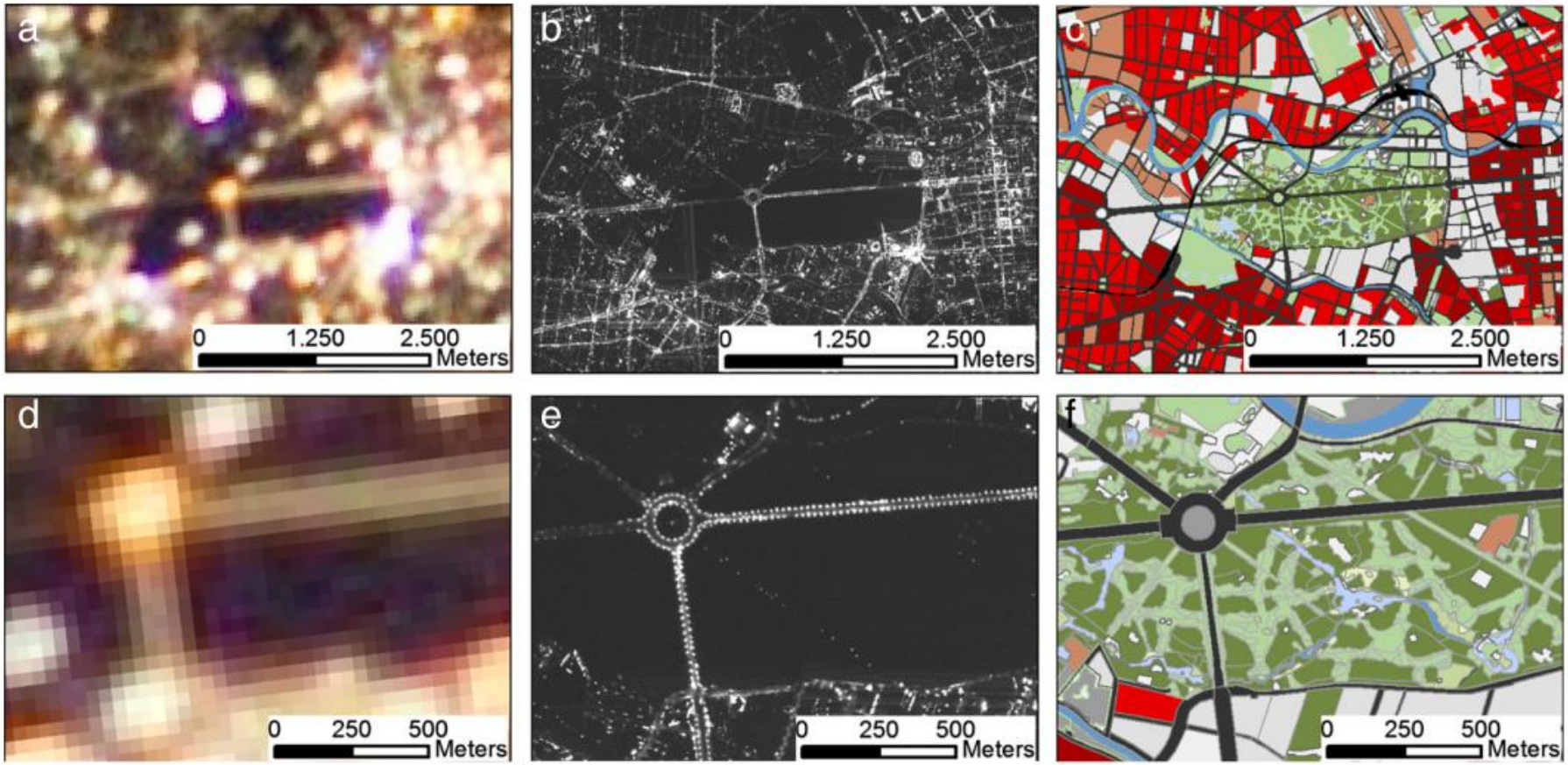


Result highlights



DMSP 2006 data

Result highlights



ISS
(45m resolution)

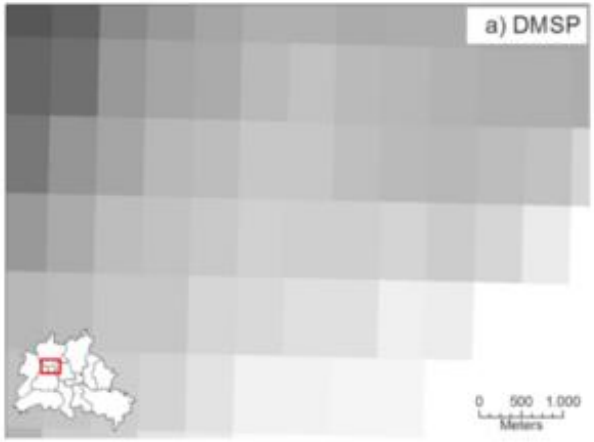
Aerial mosaic
(1m resolution)

Remote Sensing: Kyba 2015

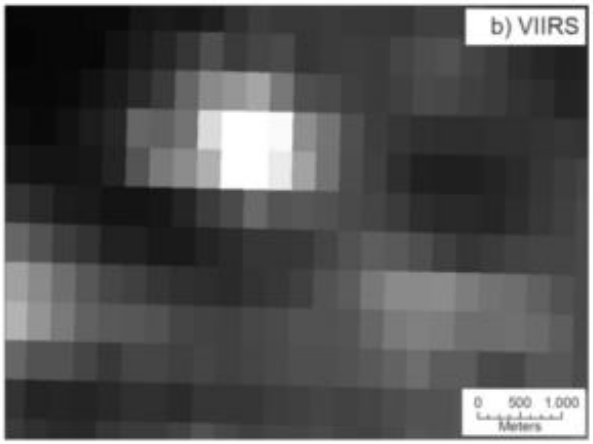
Kyba, C. et. al. 2015, Remote Sensing, 7, 1

- Data: OLD-DMSP, DNB-VIIRS, ISS, aerial
- Locations: 6 European cities, USA

Tegel airport in Berlin, Germany



OLD-DMSP
(~2.7km)

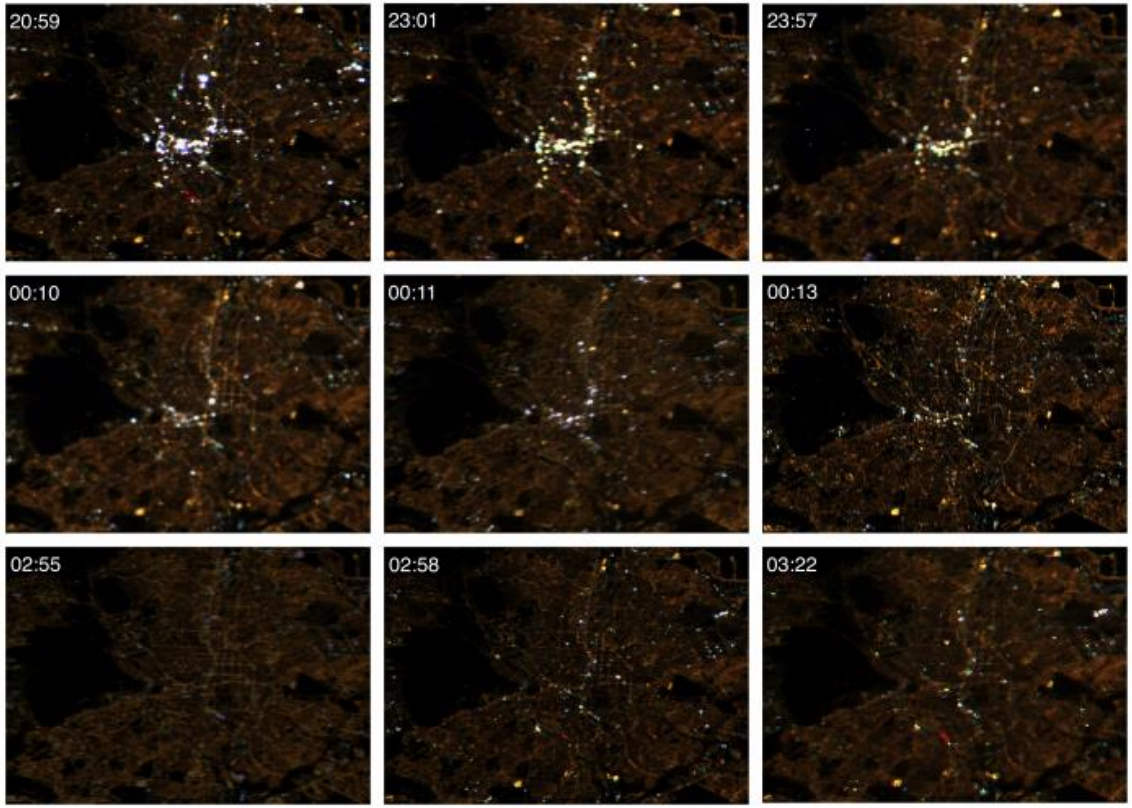


DNB-VIIRS
(~750m)

aerial
(~1m)

Result highlights

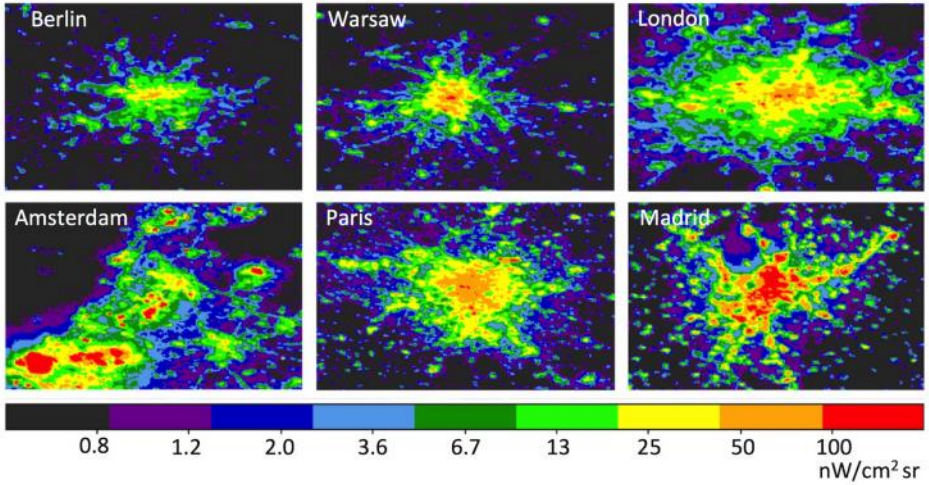
- City light changes dynamically over the course of the evening



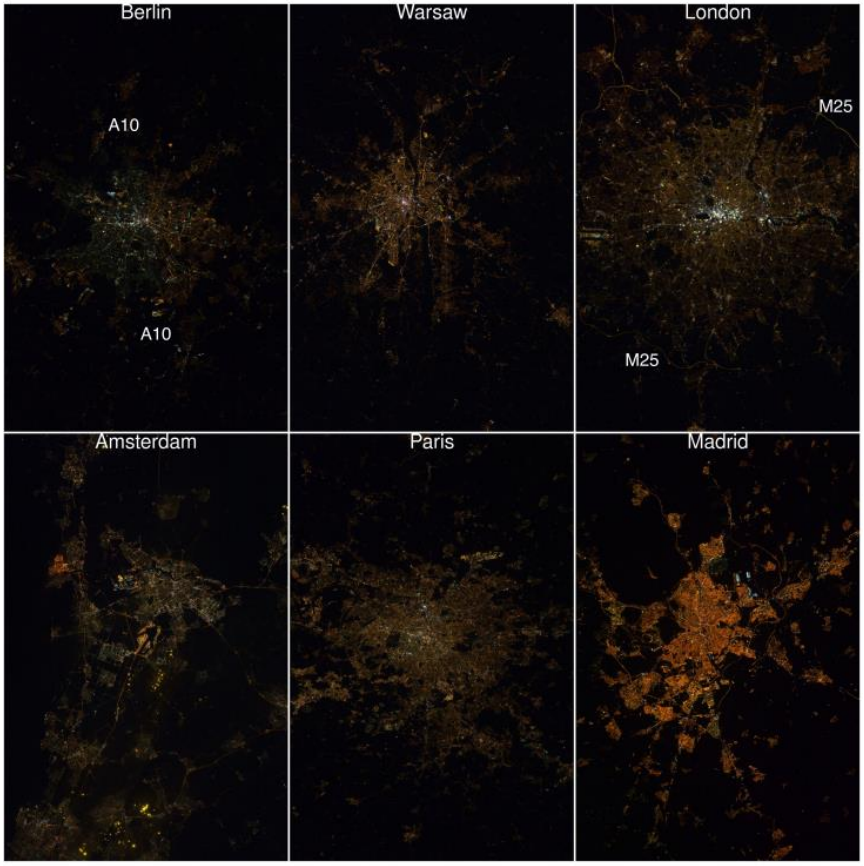
ISS images of Madrid at different times of night

Result highlights

- Difference patterns in light emission in different cities



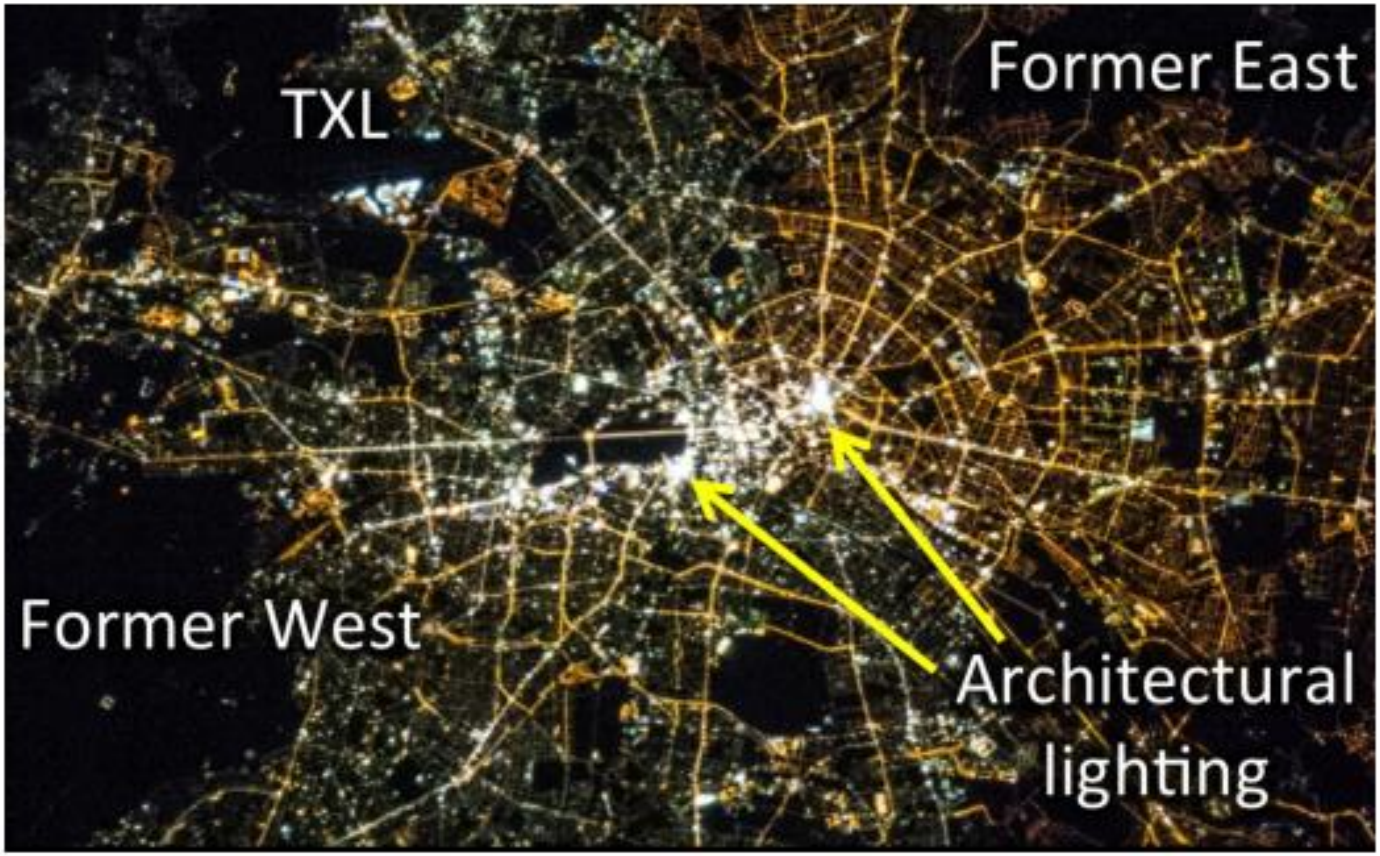
Upwelling radiance of six European cities in the VIIRS two-month composite dataset



ISS images of six European cities

Result highlights

- Different lighting sources



color difference of many of the smaller streets in the former East (orange) and West (white) in Berlin from ISS image

Citizen science

- Count the number of star visible by naked eyes
- Equipment: eyes
- Advantages:
  - Required no special skills other than identification of constellations
  - Large geographical & temporal coverages with low cost
  - Estimate light pollution condition near city centers
  - Spread of messages of dark sky conservation
- Disadvantages:
  - Photometric error would be very large (particularly projects with visual observations)

Citizen science: Globe at Night

- Locations and data collection (2014 campaign): 20,746 observations from 103 countries / regions
- Period: since 2006

Methodology

Five Easy Star Hunting Steps:

1. Use the Globe at Night website to help find your constellation in the night sky.
2. Use the Globe at Night website to find the latitude and longitude of the location where you are making your observation.
3. Go outside more than an hour after sunset (8-10 pm local time). The Moon should not be up. Let your eyes become used to the dark for 10 minutes before your first observation.
4. Match your observation to one of 7 magnitude charts and note the amount of cloud cover.
5. Report the date, time, location (latitude/longitude), the chart you chose, and the amount of cloud cover at the time of observation. Make more observations from other locations, if possible. Compare your observation to thousands around the world!

Globe at Night 2015 Dates and Constellations

Northern Constellations

Orion

January 11-20, February 9-18, March 11-20, 2015

Leo

April 9-18, May 9-18, 2015

Southern Constellations

Orion

January 11-20, February 9-18, 2015

Crux

March 11-20, April 9-18, May 9-18, 2015

Result highlights

Result highlights

Kyba, C. et. al. 2013, Scientific Reports, 3, 1835

- Naked eye limiting magnitude strongly correlates with the observed values of emitted light measured by the DMSP (worldwide) and estimated from the World atlas of artificial skyglow (European and North America)
- Standard deviation of an individual observation at 1.2 mag arcsec^{-2}

Dedicated NSB measuring devices

- Semi-conductor light sensors
- Equipment: DigiLum luminance meter, Mark Light Meter, Sky Quality Meter (SQM), etc
- Advantages:
  - Balance between accuracy ($\pm$0.1 mag arcsec^{-2}) and cost ($\sim$USD 300 per unit)
  - Easy to use
  - High data sampling frequency (several seconds)
- Disadvantages:
  - Single band measurement
  - Lacking directional NSB information

Dedicated device: Puschnig et. al. (2014)

Puschnig, J. et. al. 2014, Journal of Quantitative Spectroscopy & Radiative Transfer , 139, 64

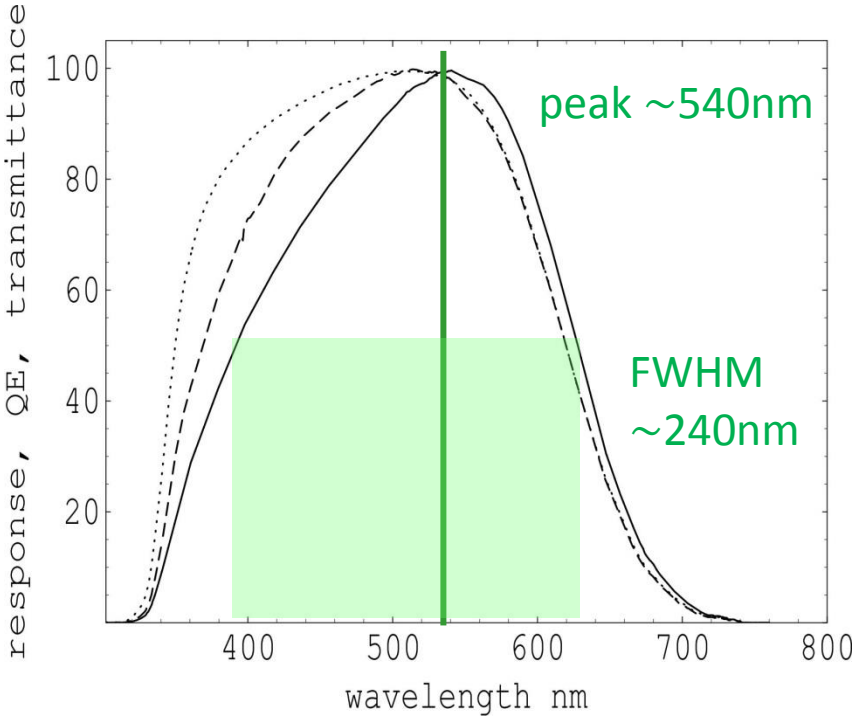
- Location: Vienna (one urban, one rural)
- Sensor: Sky Quality Meter - Lens Ethernet (SQM-LE)
- Period: Mar 2012–Mar 2013
- Data collection: every 7 seconds throughout the evening, more than $2x10^6$ individual data points at urban Vienna

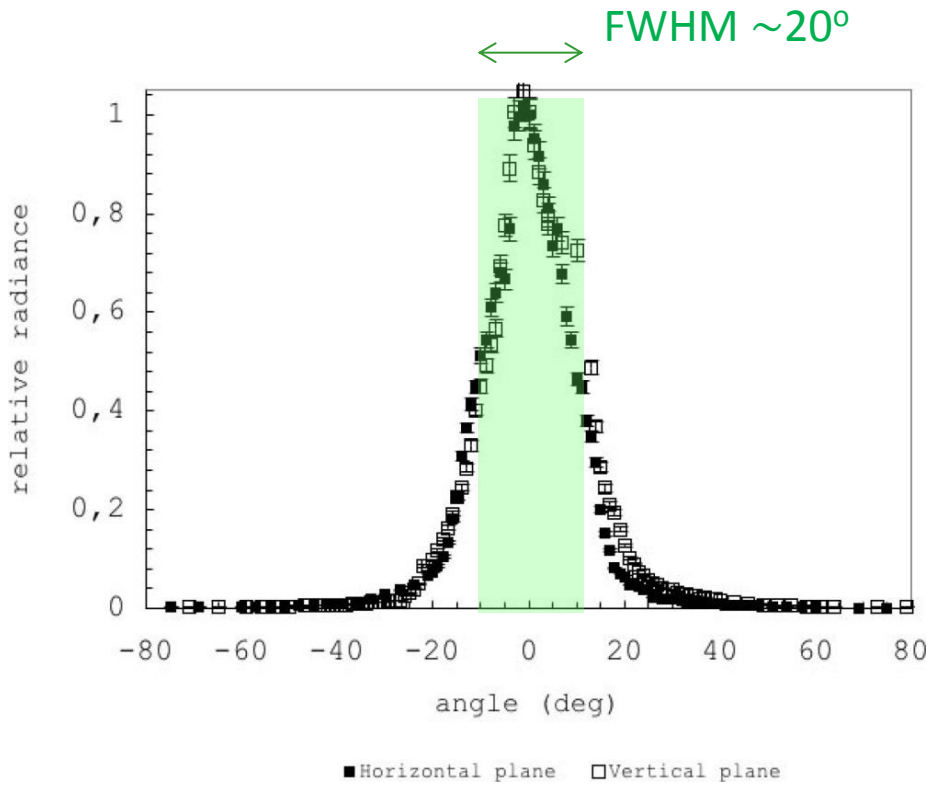
Methodology

Figure source: Unihedron

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

Methodology





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

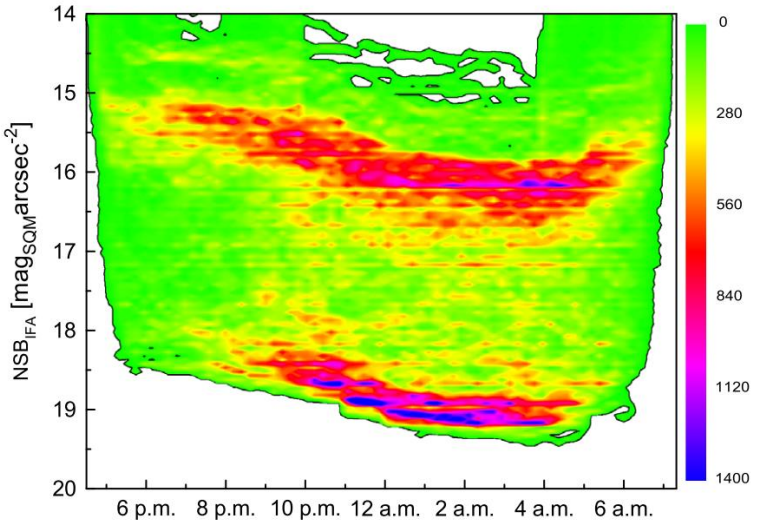
(Cinzano 2005)

Angular response function of SQM-LE

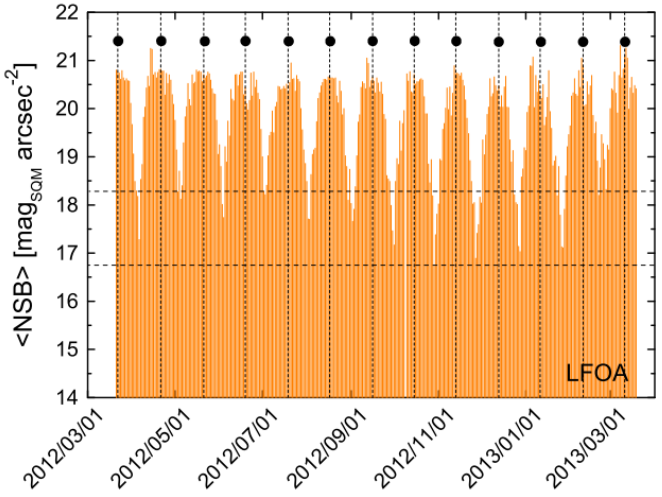
(Cinzano 2007)

Result highlights

- Detailed temporal variations of NSB
  - Curfews at 11pm and mid-night, thunderstorms, firework
- Effects of NSB vs cloud amount and moonlight identified



NSB density plot @ Vienna



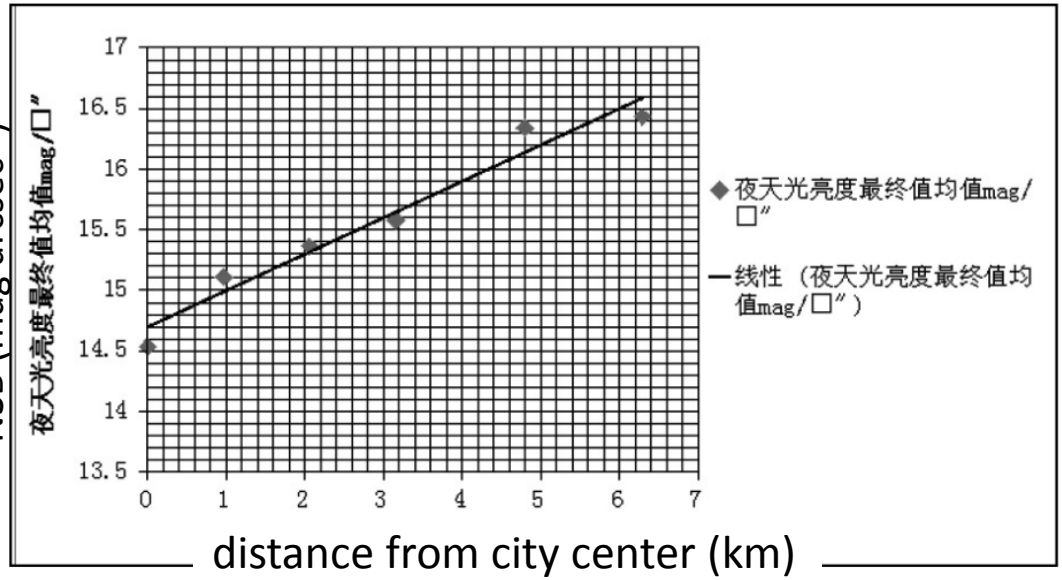
moonlight impacts on rural NSB observations

Dedicated device: Feng et. al. (2014)

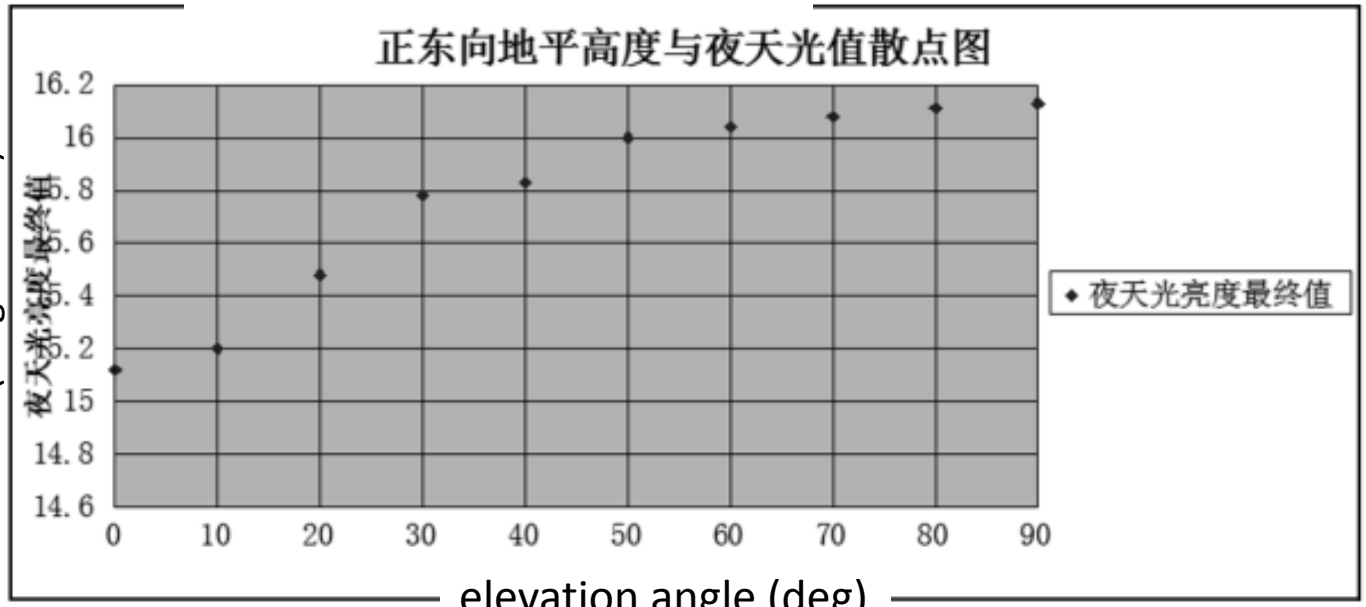
Feng et. al. 2014, Geography Teaching, 4, 61 (in Chinese)

- Astronomy club of a local high school
- Location: over 10 locations in Wuxi, Jiangsu province, China
- Sensor: 9 SQM-L
- Data collection: NSB in different locations, change in NSB from zenith distance, etc

Result highlights



Strong positive correlation between NSB and distance from city center



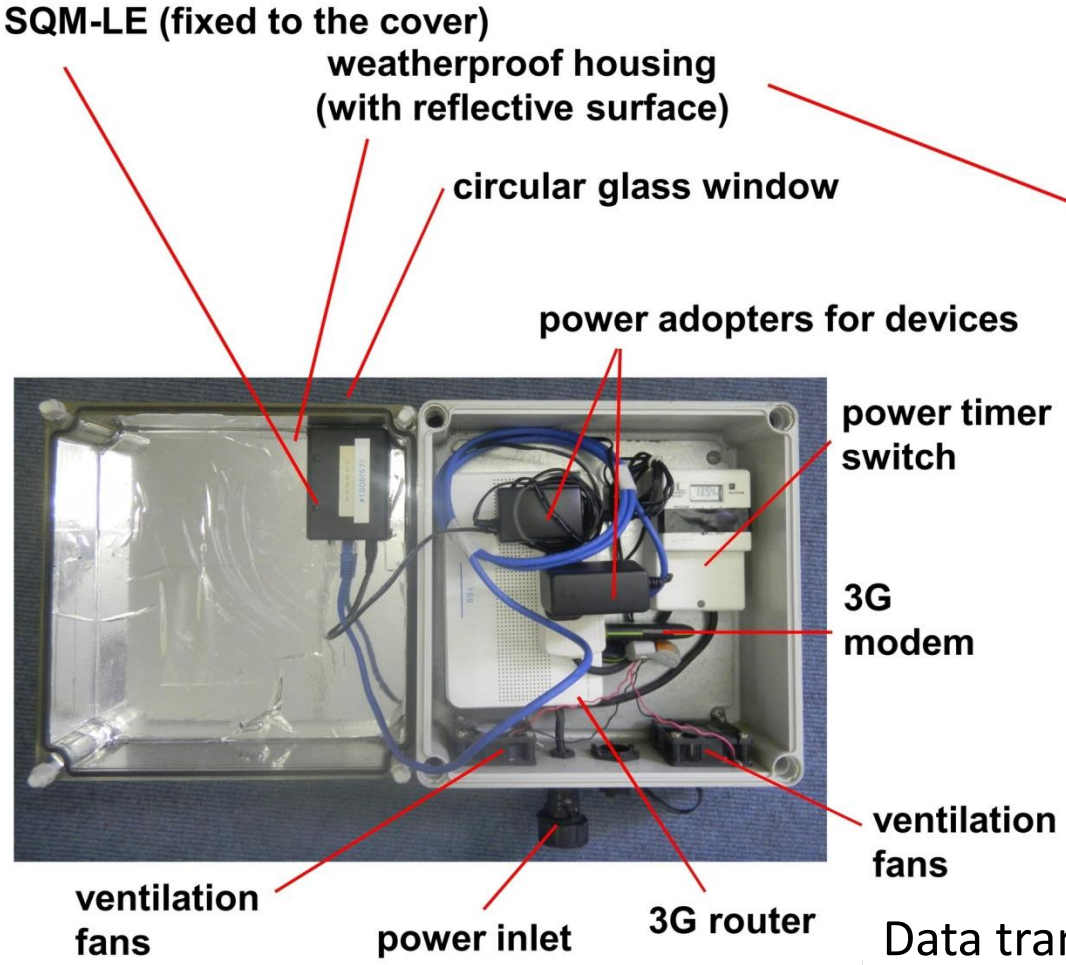
Increase in NSB with decreasing angle off horizon

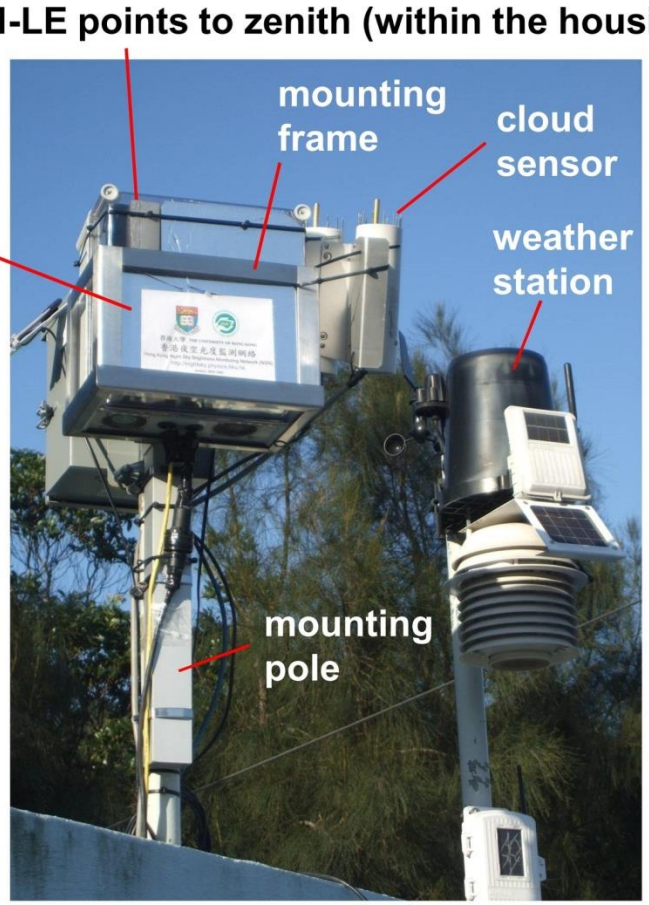
Dedicated device: Pun et. al. (2014)

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

- The Hong Kong Night Sky Monitoring Network (NSN)
- Coverage: 18 locations in Hong Kong (10 urban, 6 rural, 2 not-classified)
- Sensor: SQM-LE
- Period: May 2010 – now
- Data collection: every 1 to 5 minutes throughout the evening, 4.6 million data points reported
- Live data display: (1) project webpage http://nightsky.physics.hku.hk/; 2 (weather agency) http://www.hko.gov.hk/gts/astronomy/astro_portal.html

Methodology





Data transfer through 3G network, no fixed internet connection required

Methodology

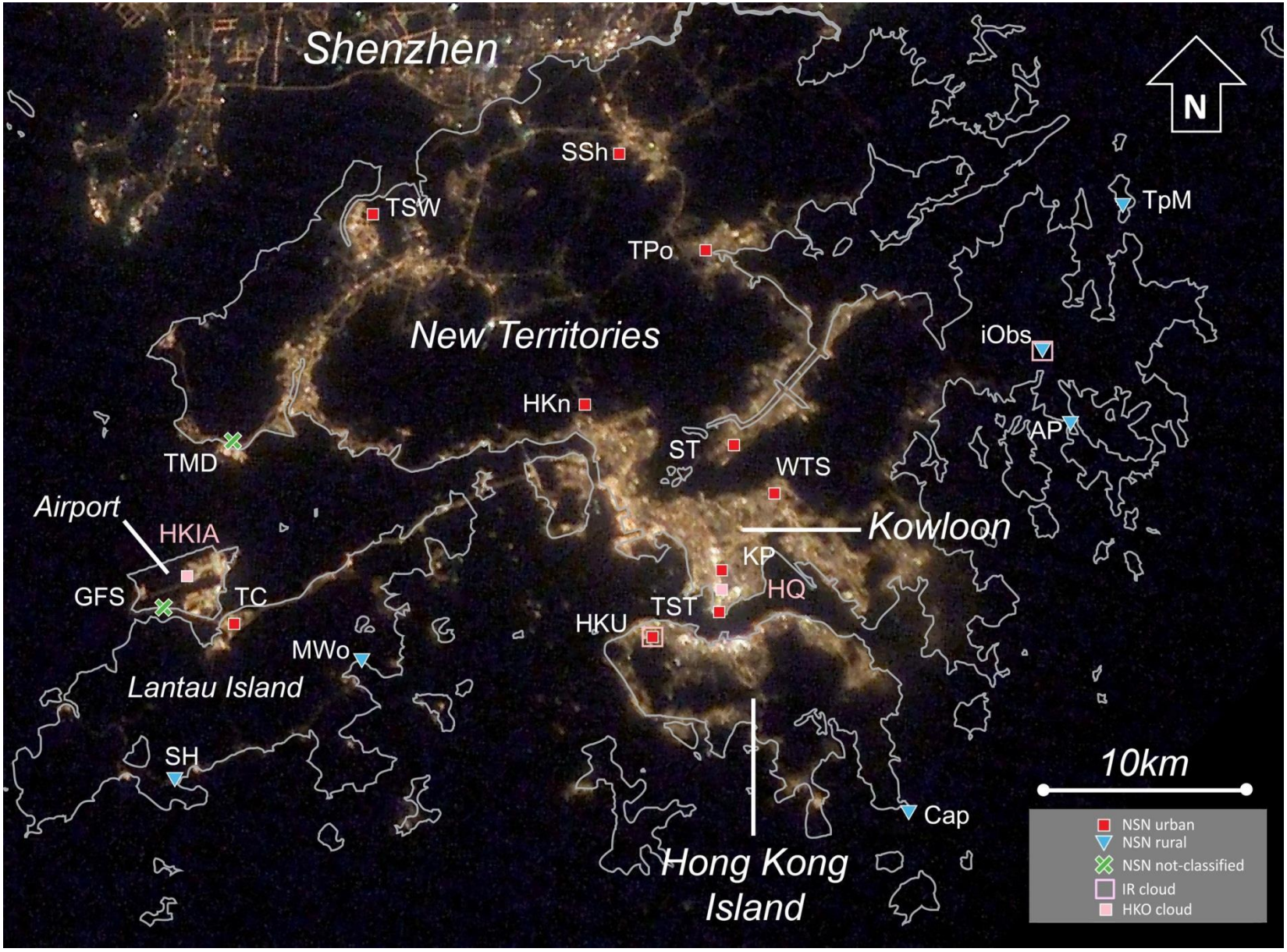
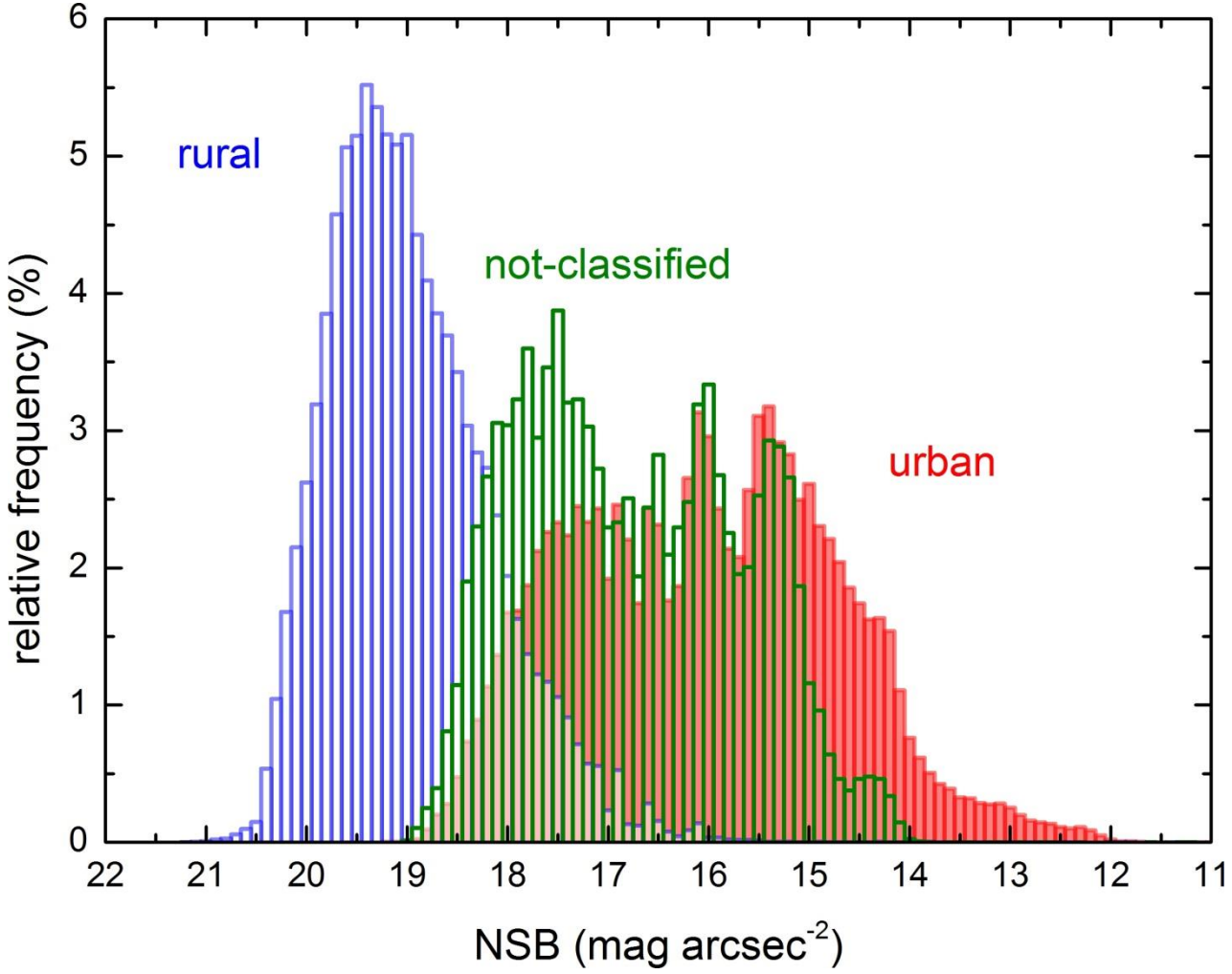


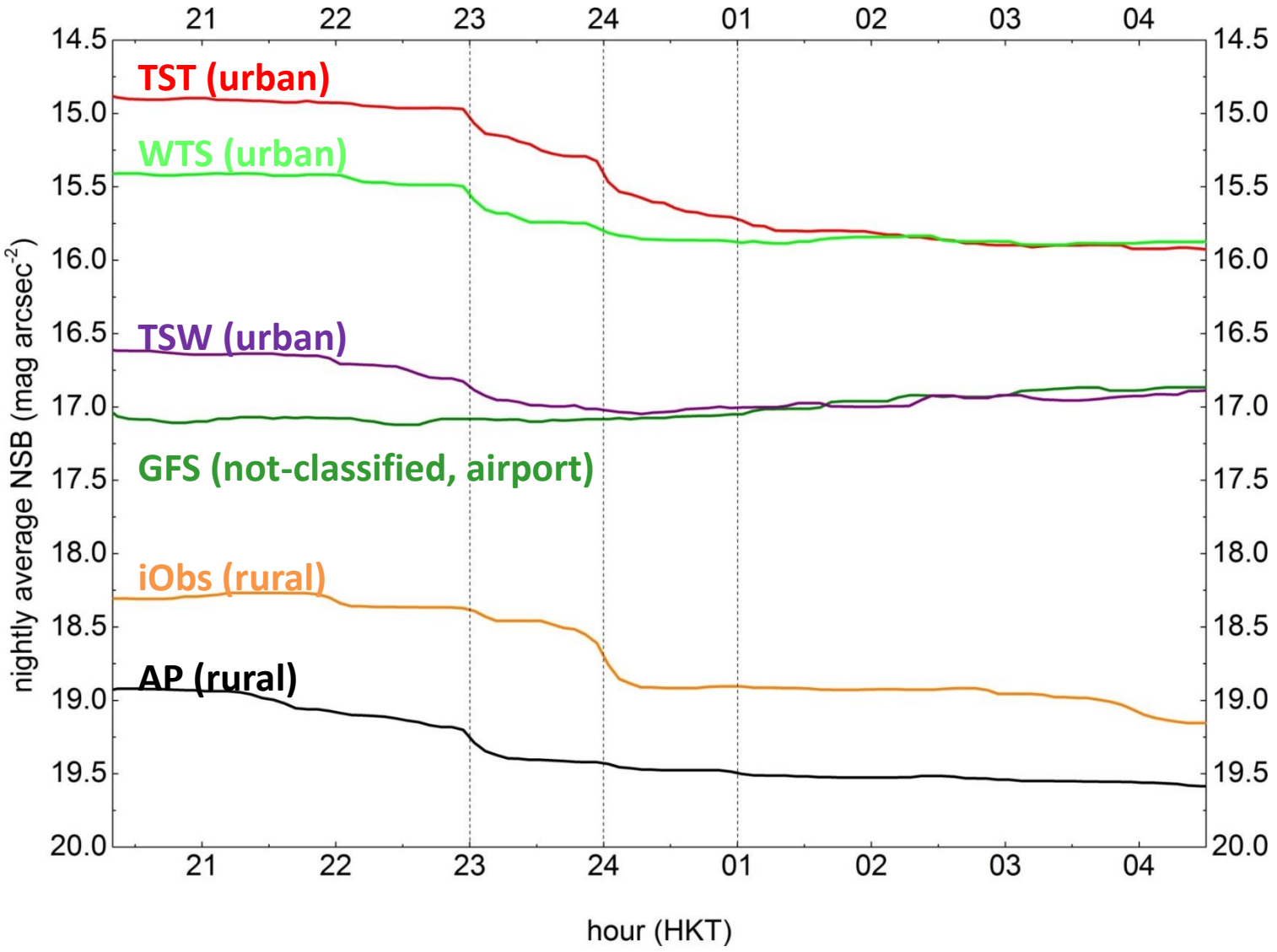
Image courtesy of Image Science and Analysis Laboratory, NASA-Johnson Space Center, The Gateway to Astronaut Photography of Earth

Result highlights

- NSB depends on location

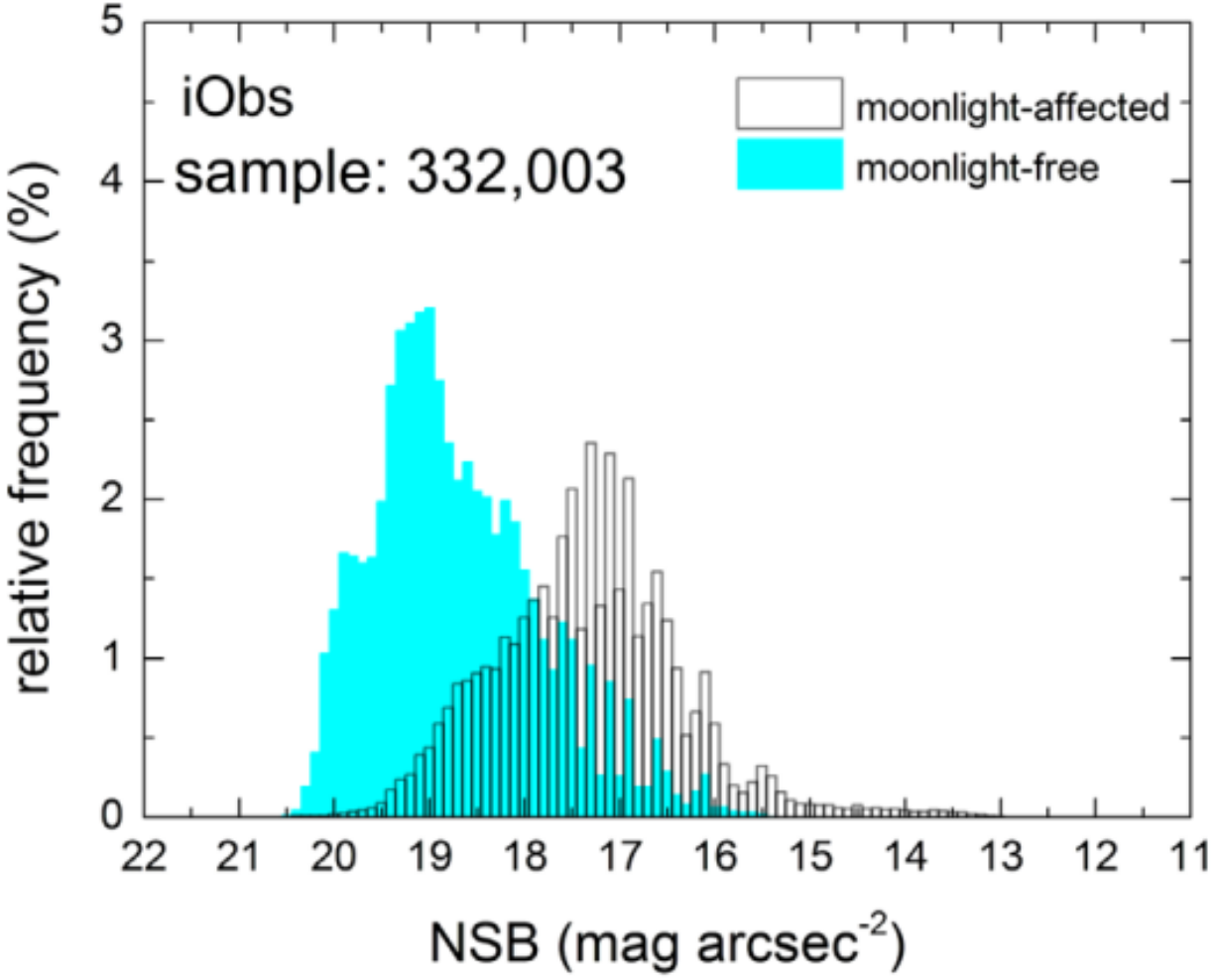


Result highlights
- NSB depends on time



Result highlights

- moonlight impacts on rural NSB observations



Night Sky Spectroscopy

- Equipment:
  - Spectrograph
  - Telescope (optional)
  - CCD camera
- Advantages:
  - Identify the sources of light pollution (type of lighting, e.g., high pressure sodium lamps, mercury lamps, etc) by studying features detected in the sky spectra
- Disadvantages:
  - No single “standard” spectrum of lamp
  - Absolute calibration a challenge (e.g., need spectrophotometric standard stars)

Night sky spectroscopy: Patat (2003)

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

- Location: Very Large Telescope (VLT), La Silla Paranal Observatory, Chile
- Telescope: 8.2m ESO Antu/ Melipal telescope
- Sensor: FOcal Reducer/low Dispersion Spectrograph (FORS1)
- Slit and grism: 1” long slit and 150I grism
- Period: 25 Feb 2001 (moonless)
- Data cllection: high signal-to-noise, flux calibrated night sky spectrum

Result highlights

- Light-polluted lines e.g., Hg I (3650, 3663, 4047, 4078, 4358 and 5461 Å) and NaI (4978, 4983, 5149 and 5153 Å) very weak in the Paranal's sky spectra

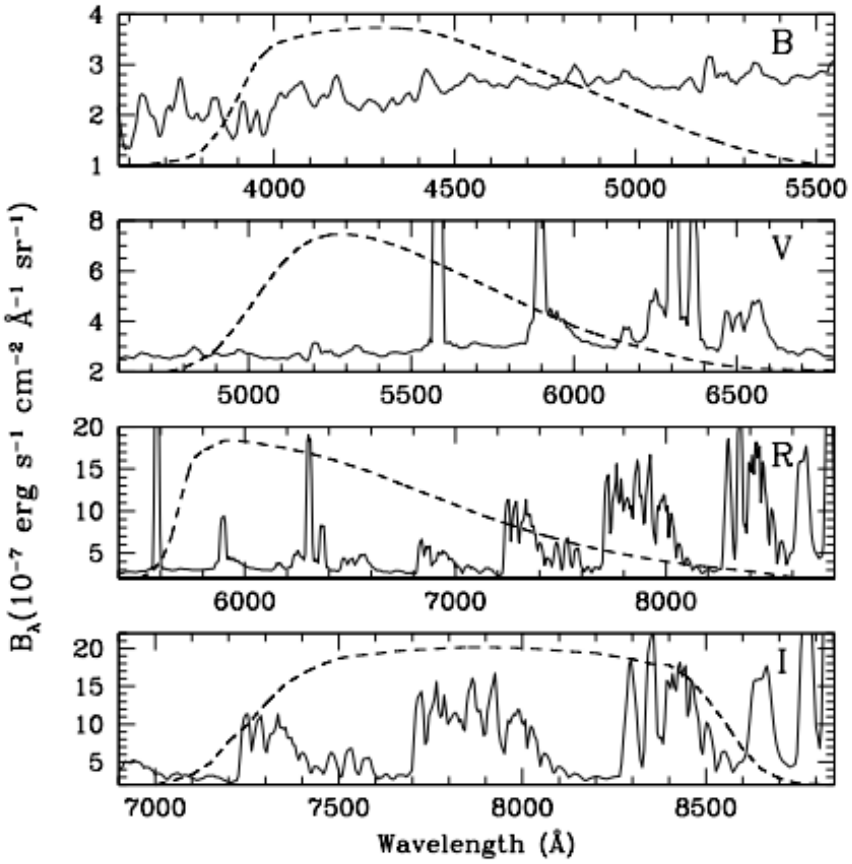


Fig. 1. Night sky spectrum obtained at Paranal on February 25, 2001 02:38UT in the spectral region covered by *B*, *V*, *R* and *I* passbands (from top to bottom). The original FORS1 1800 s frame was taken at 1.42 airmasses with a long slit of 1″ and grism 150I, which provide a resolution of about 22 Å (*FWHM*). The dashed lines indicate the passband response curves. Flux calibration was achieved using the spectrophotometric standard star Feige 56 (Hamuy et al. 1992) observed during the same night. The absence of an order sorting filter probably causes some second order overlap at wavelengths redder than 6600 Å.

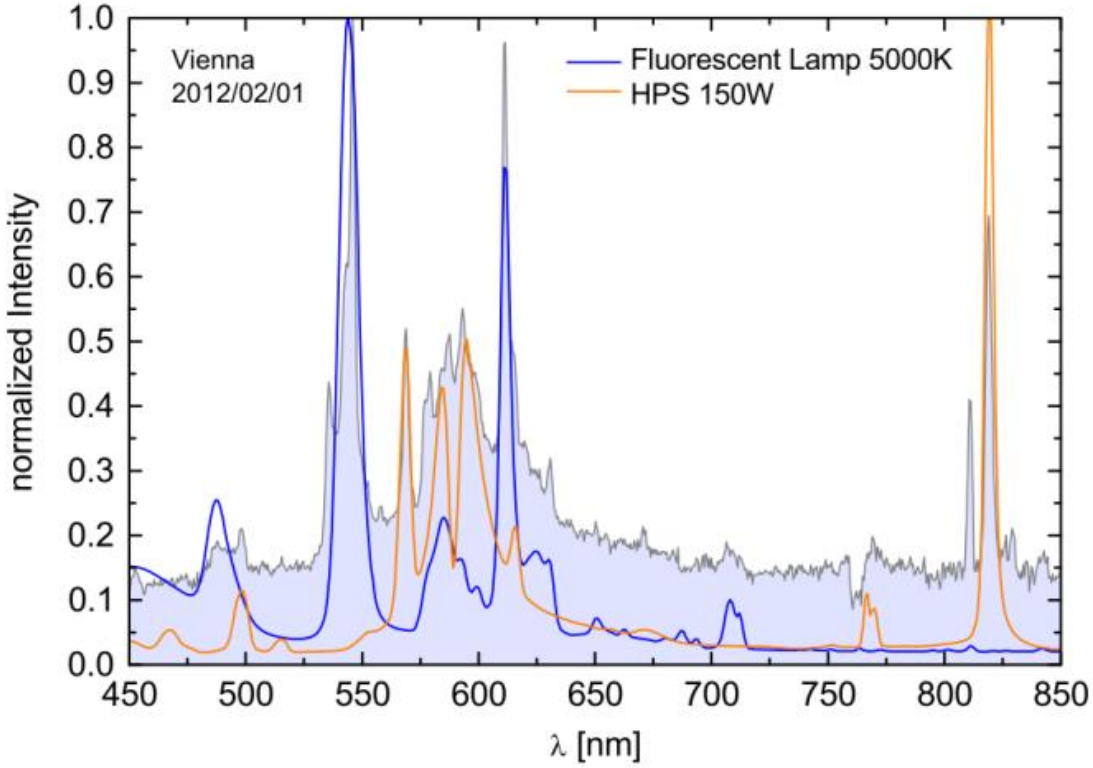
Night sky spectroscopy: Puschnig et. al. (2014)

Puschnig, J. et. al. 2014, Journal of Quantitative Spectroscopy & Radiative Transfer , 139, 64

- Location: Vienna University Observatory
- Spectrograph: SBIG DSS-7 + ST7
- Telescope: 0.8 m in diameter
- Period: 1 February 2012
- Data collection: point the telescope to the south or to the south-east (i.e. towards the city center of Vienna) at an elevation of ~45deg, 300s integration time

Result highlights

- Strong spectral lines detected at 546 nm (fluorescent lamps, common in residential areas) and 611 nm (high pressure sodium, use in streetlamps and highway lamps)



Others - Cometary (Ściężor 2013)

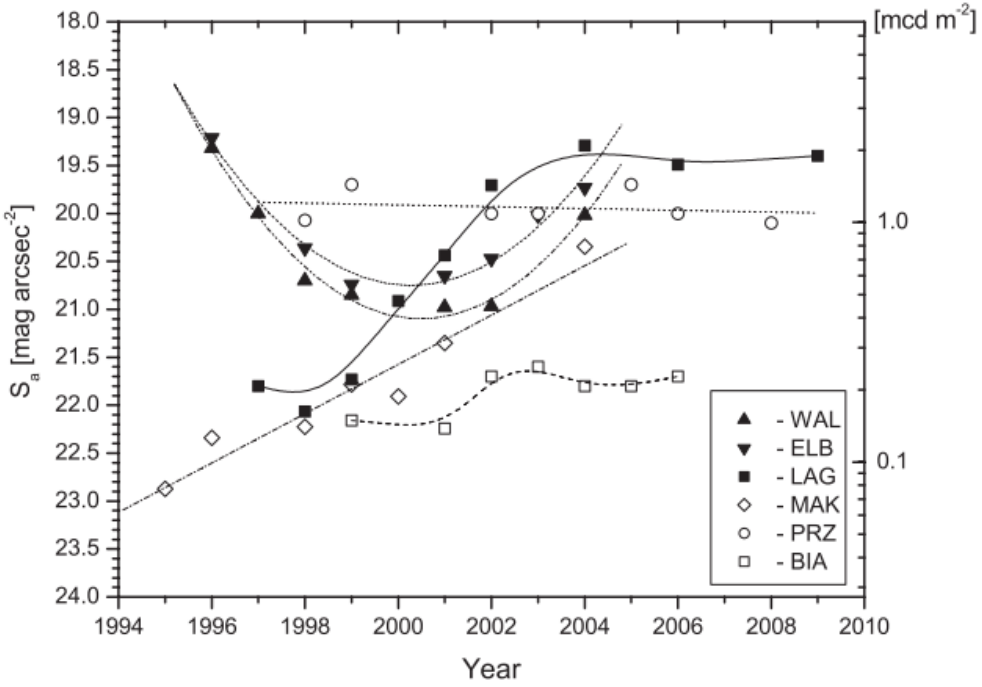
Ściężor T., 2013, Monthly Notices of the Royal Astronomical Society, 435, 303

- The method is based on measurements of the surface brightness of the faintest diffuse objects visible in the sky.
- DC value: describes the degree of condensation of the comet on the sky background
  - DC = 0 indicates totally diffuse; DC = 9 means stellar
- surface brightness of the weakest comet (DC=0, 1 or 2) can be used as an approximate value of NSB
- Advantages:
  - If archival observations of comets are available, NSB in the past can be traced back to determine long-term changes in NSB.
- Disadvantages:
  - Results depends on observer skills and experiences.

Others - Cometary (Ściężor 2013)

Ściężor T., 2013, Monthly Notices of the Royal Astronomical Society, 435, 303

- Location: several locations in Poland
- Period: 1994 - 2009
- Comet observations: 451 comet observations (comets dimmer than 7 mag)



- Result highlights:
  - no change in NSB in ecologically clean areas
  - clear increase in light pollution for sites located on the border of heavily light-polluted and less light-polluted areas
  - clear decrease in light pollution for sites had fall in industry

Night Sky Brightness Measurements

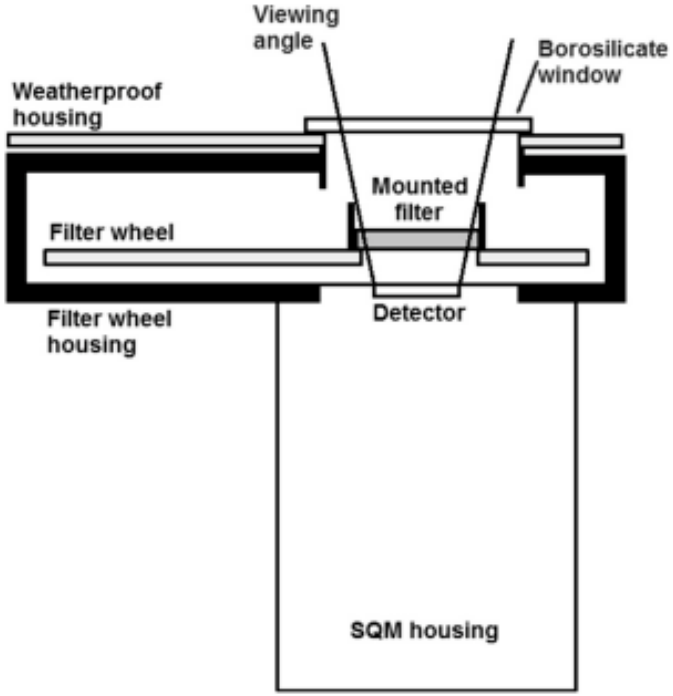
	Application	Geographic coverage	Temporal coverage	Cost	Accuracy	Major pro	Major con
Traditional CCD photometry	Analyze night sky properties of a site in detail	👍	👍	👍	👍👍👍	High accuracy	High cost
Wide-field photometry	Analyze sources of light pollution	👍👍	👍👍	👍👍	👍👍	Directional information	Calibration challenge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

Measurement of Light Pollution: Prospects

- Combining features of different methods for better results
- Take advantage of the dedications of citizens beyond communities of amateur astronomers
- Take advantage of the widespread technology available
- Long-term spectroscopic (at least multi-band) monitoring of night sky at urban locations
- Connecting the remote-sensing data and the ground-based night sky measurements (looking down vs looking up)

Dedicated device + Multi-band observation

Spoelstra, H. 2014, Journal of Quantitative Spectroscopy & Radiative Transfer , 139, 82
Kyba, C. et. al. 2012, Monthly Notices of the Royal Astronomical Society, 425, 701



Spoelstra (2014): 5 color filters on a wheel

Kyba et. al. (2012): 5 SQMs with different filters

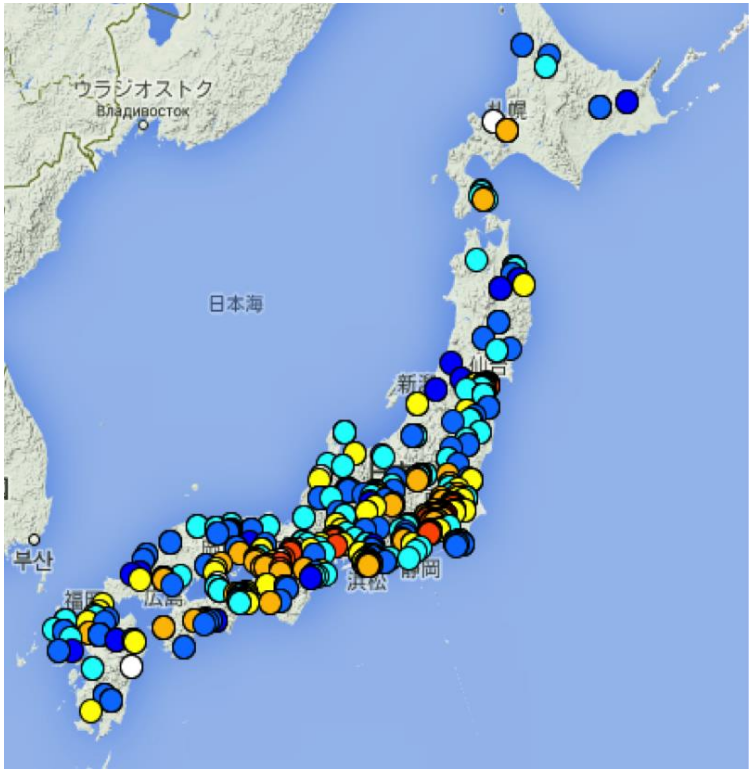
- Results highlights:
  - More blue light when the night sky is clear (Spoelstra, 2014)
  - Red is the new black (Kyba et. al. 2012)

Citizen science + converted-NSB meter: Dark Sky Meter IYL 2015 Edition (iPhone app)

Citizen science + Wide-field photometry: Hoshizora Kodan (the alliance of starlight distributors)

See more: http://dcdock.kodan.jp/?lang=en

- Location: over 2,000 points in Japan
- Equipment: commercial Digital Single Lens Reflector camera (DSLR)
- Both automatic-fixed and temporary set up
- Filters: N/A (RGB in sensor)
- Period: 2008+



We recommend digital still camera with RAW format which releaseed after 2008.

Canon

EOS 1D Mark IV, EOS-1D X, EOS 5D Mark II*, EOS 5D Mark II(sRAW)*, EOS 5D Mark III, EOS 5Ds, EOS 5Ds R, EOS 6D*, EOS 6D(sRAW), EOS 60D*, EOS 60D(sRAW), EOS 60Da, EOS 7D*, EOS 7D Mark II, EOS 50D*, EOS 60D, EOS 70D, EOS 8000D, EOS Kiss F*, EOS Kiss X2*, EOS Kiss X3*, EOS Kiss X4*, EOS Kiss X5*, EOS Kiss X50*, EOS Kiss X6i*, EOS Kiss X7i, EOS Kiss X7, EOS Kiss X70, EOS Kiss X8i, EOS M, EOS M2, EOS M3

NIKON

D3X, D3s, D4, D4s, Df, D300S*, D700*, D800*, D800E, D600*, D600(DX), D610, D810, D750, D60*, D90*, D3000, D3100, D3200, D3300, D5000*, D5100*, D5200, D5300, D5500, D7000*, D7100, D7200, 1 V1, 1 V2, 1 V3, 1 J1*, 1 J2, 1 J3, 1 J4, 1 J5, 1 S1, 1 S2, 1 AW1

OLYMPUS

E-5*, E-30, E-420*, E-520, E-620, E-P1*, E-P2, E-P3, E-P5, E-PL1, E-PL1s, E-PL2, E-PL3, E-PL5, E-PL6, E-PL7, E-PM1, E-PM2, E-M5*, E-M1, E-M10, E-M5 Mark II

Panasonic

DMC-G1*, DMC-GH1, DMC-GF1, DMC-G2, DMC-G10, DMC-GH2*, DMC-GF2, DMC-G3*, DMC-GF3, DMC-GX1, DMC-GF5, DMC-G5, DMC-GH3, DMC-GF6, DMC-G6, DMC-GX7, DMC-GM1, DMC-GH4, DMC-GM1s, DMC-GM5

PENTAX

K200D*, K20D*, K-m, K-7, K-x, K-r*, K-5*, K-30, K-5 II, K-5 II s, K-50, K-3, Q, Q10, Q7, K-01*

SONY

DSLR-A200, DSLR-A350, DSLR-A300, DSLR-A900, DSLR-A230, DSLR-A330, DSLR-A380, DSLR-A550, SLT-A55, SLT-A33, SLT-A77V, SLT-A65V, SLT-A57, SLT-A37, SLT-A99, SLT-A58, ILCA-77M2, NEX-3*, NEX-C3, NEX-F3, NEX-3N, NEX-5, NEX-5N, NEX-5R, NEX-5T, NEX-7, NEX-6, ILCE-5000, ILCE-5100, ILCE-6000, ILCE-QX1, ILCE-7R, ILCE-7, ILCE-7S, ILCE-7M2

RICOH

GXR A12*

*Brightness with quick measurement will shown after posting data.

Methodology

camera setup (automated)

OR

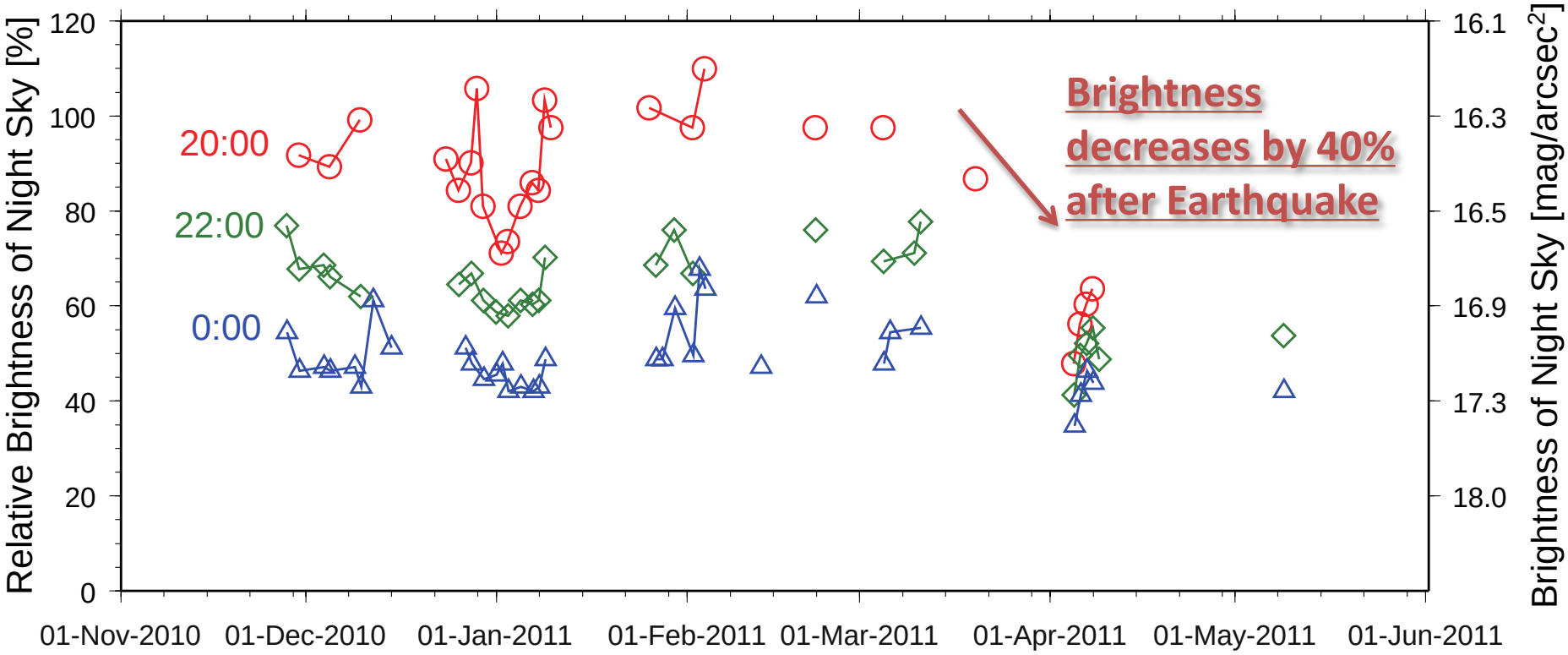
camera setup (manual)

zenith sky imaging using standard parameters

upload RAW image to an online interface

NSB extraction (auto)

Result highlights



- 2011 March 11 earthquake leads to 40% lower night-sky brightness at 20:00 in Tokyo compared with the brightness during Feb-2011.
- A consequence of power saving in the area.

The Global at Night Sky Brightness Monitoring Network (GaN-MN) globeatnight-network.org

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

INTERNATIONAL YEAR OF LIGHT 2015

- Endorsed by the IAU Executive Committee Working Group for the International Year of Light 2015 as a major Cosmic Light program
  - Expand the sky brightness monitoring network (NSN) worldwide
  - In the award letter, "Suggestions were to "*coordinate ... with others who are pursuing the educational aspect in other regions*."

COSMIC LIGHT IAU

The Global 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 Global 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

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

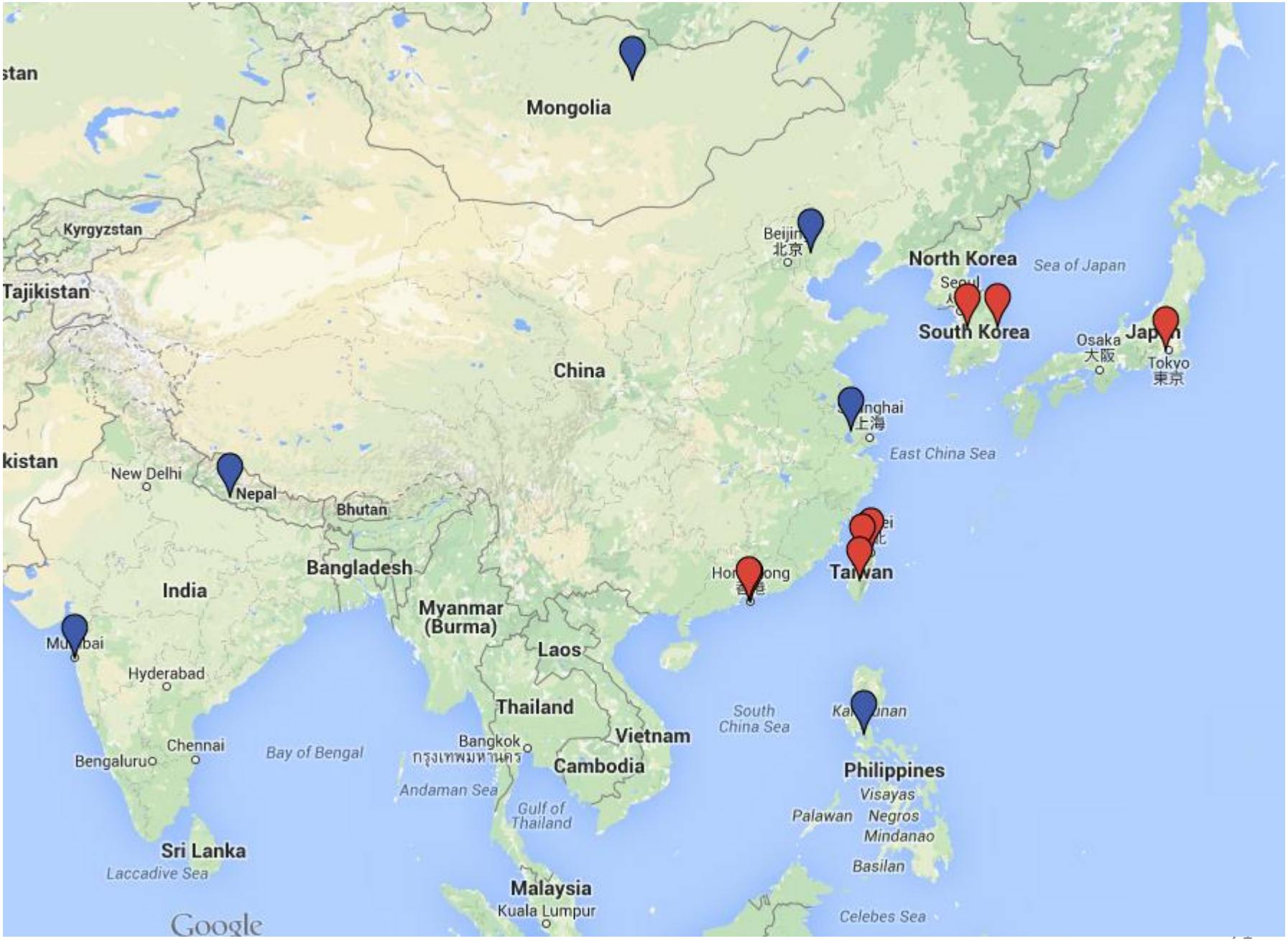
- Current stations:

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
Chungbuk National University Observatory (CNUO)	South Korea	2015-01-27
Yeongyang Firefly Astronomical Observatory (YFAO)	South Korea	2015-01-24
Lulin Observatory (LUO)	Taiwan	2015-03-27
Ho Koon Nature Education cum Astronomical Centre (HKn)	Hong Kong	2015-04-18

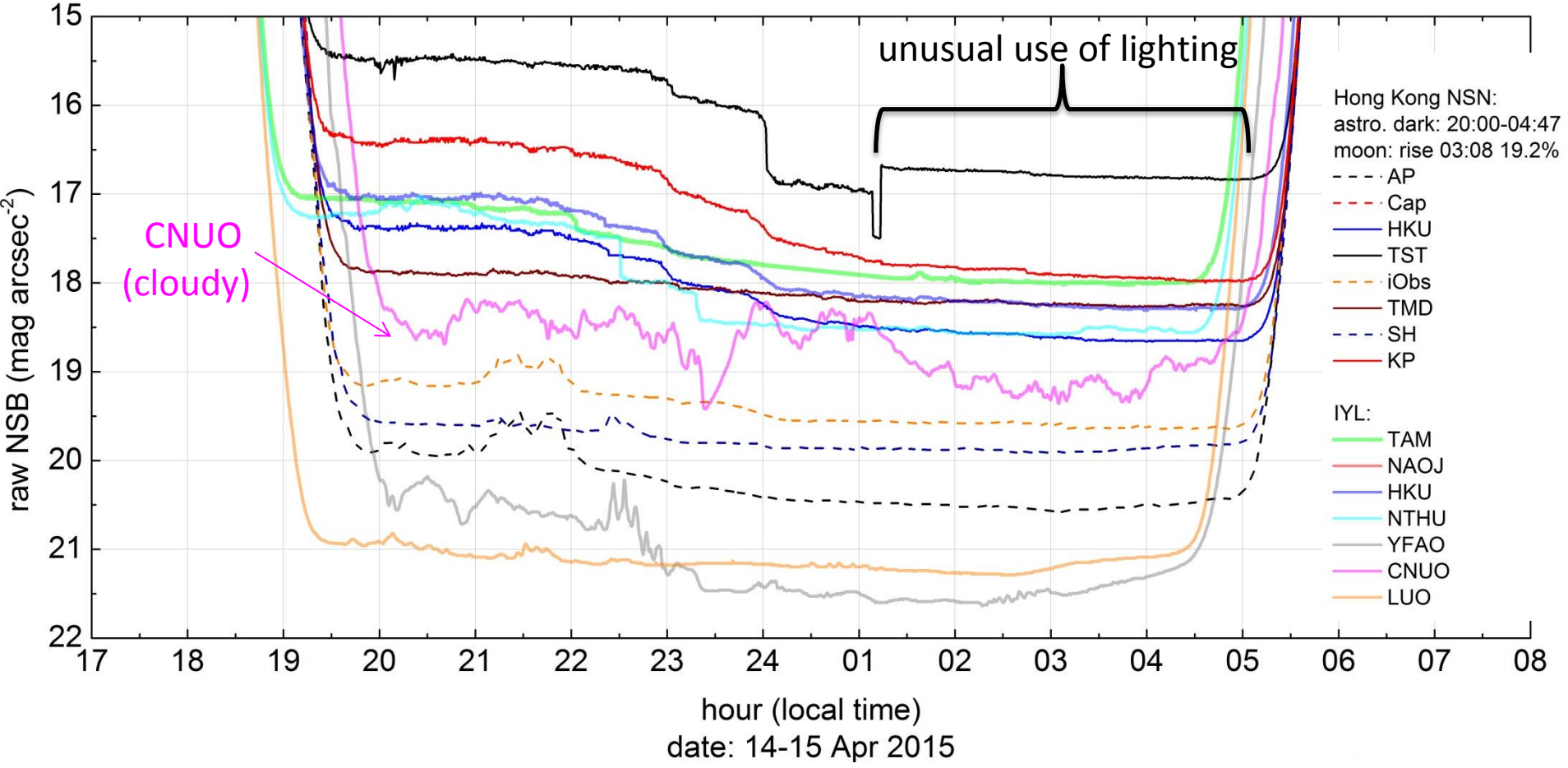
The Global at Night Sky Brightness Monitoring Network (GaN-MN)

- Stations under planning (more are coming!):

Organization	Country /region
Korean Astronomy and Space Science Institute (KASI) (x10 purchased)	South Korea
National Tsing Hua University (~ 6 – 8)	Taiwan
National University of Mongolia	Ulan Bator, Mongolia
Xinglong Observing Station of National Astronomical Observatories, Chinese Academy of Science	Beijing, China
Tianyi Astronomical Society, Jiangsu Tianyi High School (x10)	Wuxi, China
Regulus SpaceTech/Science Education Institute	Manila, Philippines
Nepal Sanskrit University	Kathmandu, Nepal
The Story of Light Festival, A project for IYL2015	Mumbai, India


Mongolia
Kyrgyzstan
Tajikistan
China
North Korea
Sea of Japan
South Korea
Osaka
大阪
Tokyo
東京
East China Sea
New Delhi
Nepal
Bhutan
Bangladesh
India
Myanmar
(Burma)
Laos
Thailand
Vietnam
Cambodia
Taiwan
Hyderabad
Chennai
Bengaluru
Bay of Bengal
Bangkok
กรุงเทพมหานคร
Andaman Sea
Gulf of
Thailand
South
China Sea
Philippines
Visayas
Palawan
Negros
Mindanao
Basilan
Sri Lanka
Laccadive Sea
Malaysia
Kuala Lumpur
Celebes Sea
Google

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



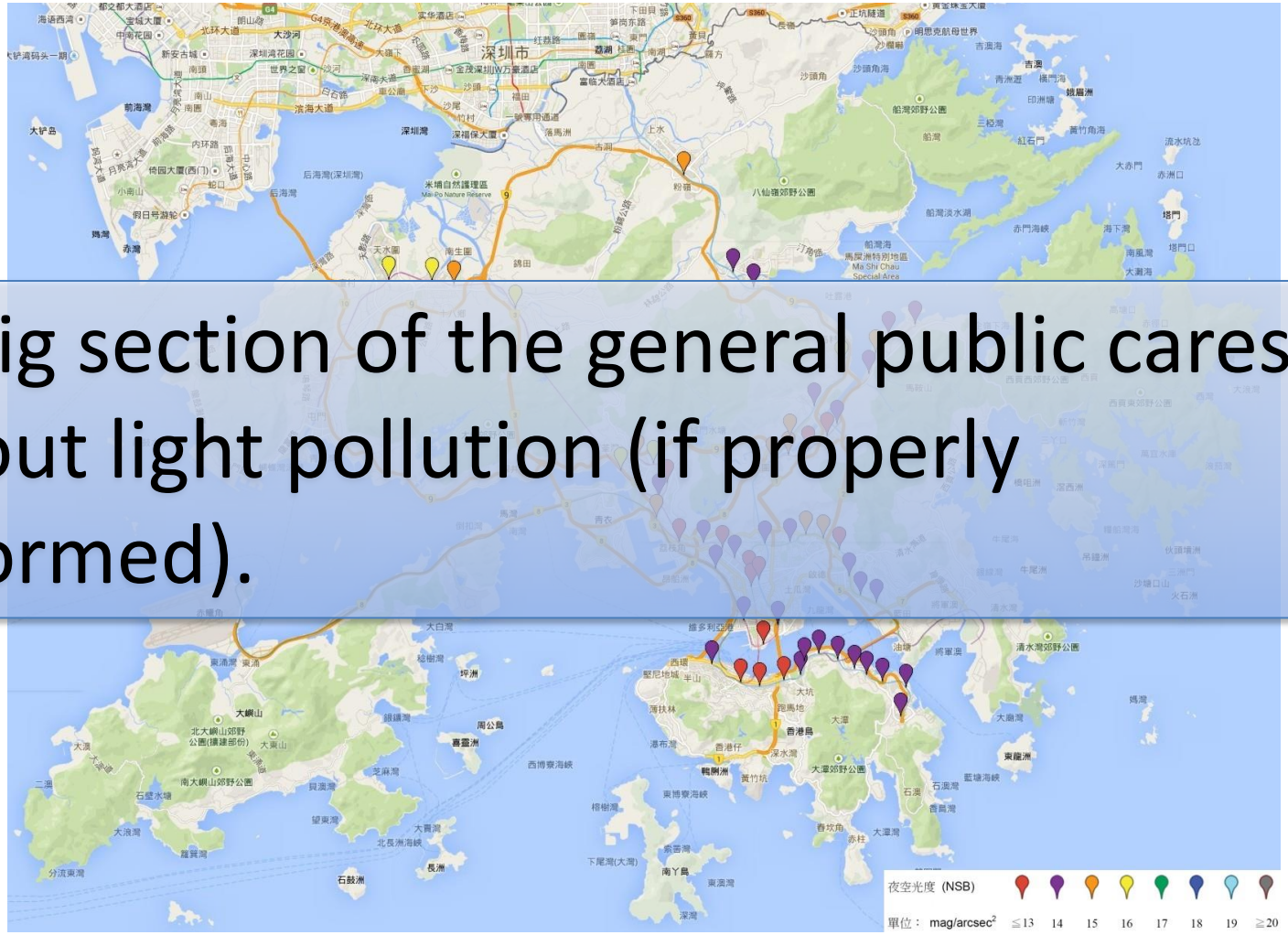
The Global at Night Sky Brightness Monitoring Network (GaN-MN)

- 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
  - Gain access to light pollution measurements from around the world
  - Let’s fight light pollution together!

Please join us!

For more information on the Globe at Night Sky Brightness Monitoring Network (GaN-MN), please visit globeatnight-network.org

Or Email us at: socw@connect.hku.hk, or outreach@iau.org



A big section of the general public cares about light pollution (if properly informed).

- Organized a Light Pollution Research Competition in Hong Kong in 2014
- Middle school students spending multiple nights taking over 100 data points going all around the city using public transportation.