

# living planet symposium **BONN** 23–27 May 2022

## N8 – Global Environmental Effects of Artificial Nighttime Lighting

N8 ≡ Night / Nacht / Nuit / Noche / Noite / ...

Tobias Storch, Martin Aubé, Salvador Bará, Fabio Falchi, Monika Kuffer, Christopher Kyba, Noam Levin, Alejandro Oscoz, Miguel O. Román, Alejandro Sánchez de Miguel, Lothar Schrott, Ralf Münzenmayer, Stefanie Riel, Kevin J. Gaston



Knowledge for Tomorrow



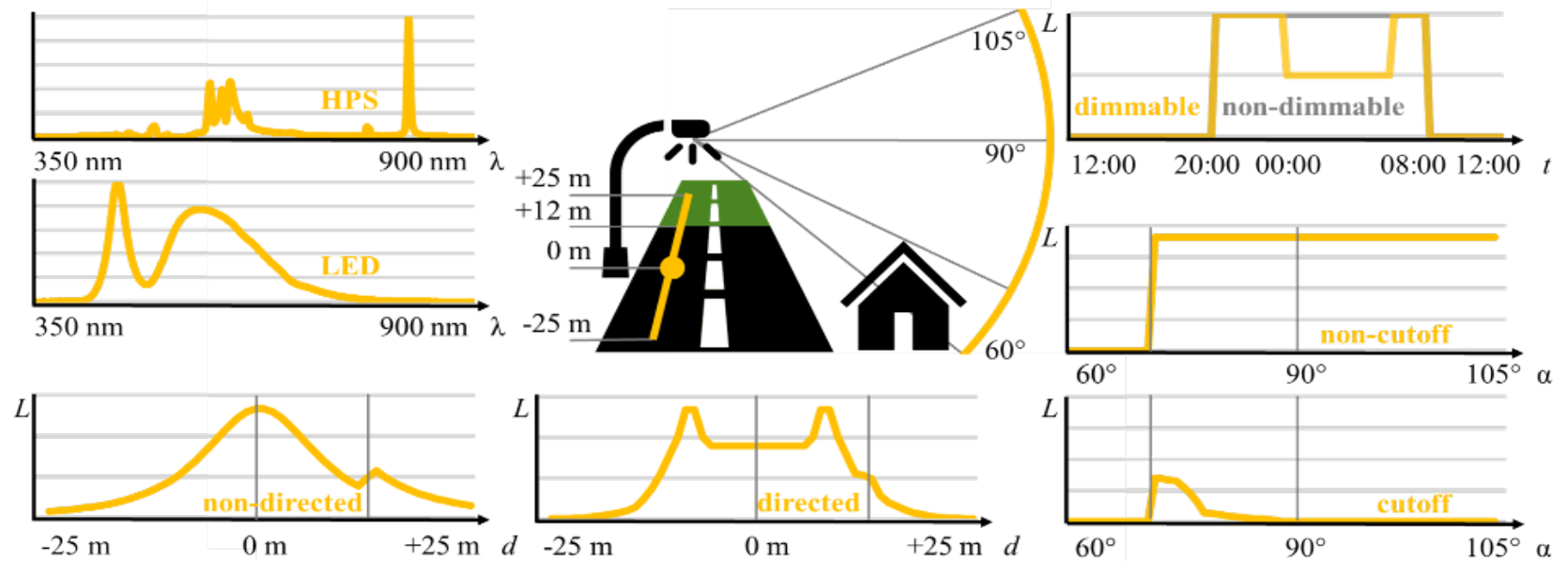


# Overview

- N8 (Global Environmental Effects of Artificial Nighttime Lighting)  
Mission Idea submitted as Earth Explorer 11
  - Scientifically recommended\*
  - Technically not recommended due to feasibility wrt performance\*
- “Mapping of [...] night-time artificial lighting [...] is a unique tool to globally monitor human presence and activity, and reveal changes [...] to] study the impact [...] on human health and environment [...] needed with high spatial resolution at different times“\*

Mapping of the spectral-spatial-temporal variation in night-time artificial lighting through satellite imagery of night-time lights would be a unique tool to globally monitor human presence and activity, and reveal changes therein, e.g. economic activities, traffic, and energy access. N8 would study the impact of night-time lights on human health and the environment / ecology, providing much needed data. Long-term night-time light data have been only available from the US DMSP/OLS and VIIRS/DNB sensors. To monitor and understand the impact of global urbanization this observable is much needed with high spatial resolution at different times at night. However, because of N8's novelty, a couple of challenging processing steps and the retrieval of geophysical parameters need to be addressed. as outlined in the proposal and the review.

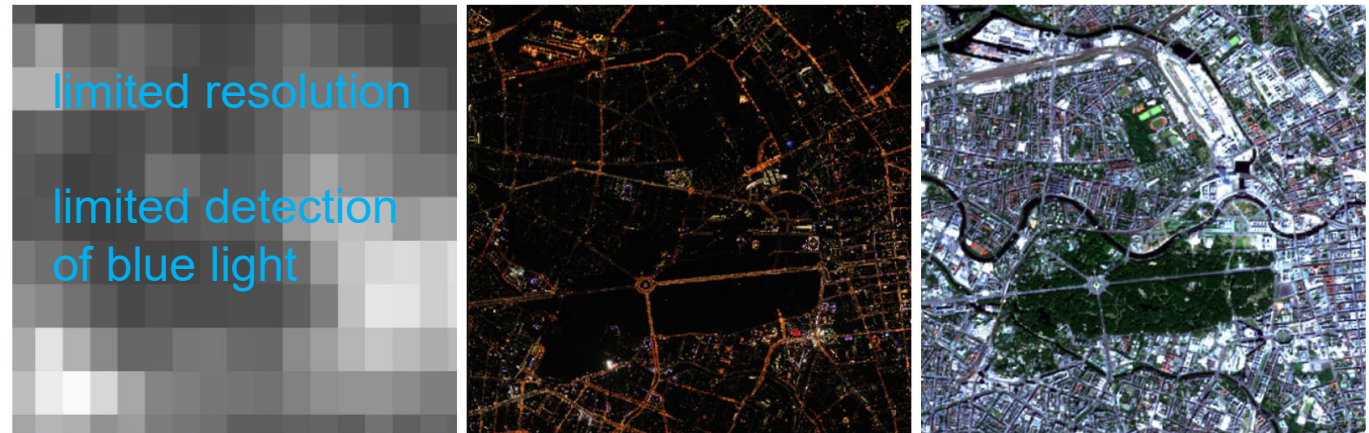
# Overview



- “Mapping of [...] night-time artificial lighting [...] is a unique tool to globally monitor human presence and activity, and reveal changes [...] to study the impact [...] on human health and environment [...] needed with high spatial resolution at different times“\*

sources associated with

- human settlements; public, private business and residential areas
- associated transport infrastructure; land, water, and air



Pan-750 m-nadir-single nighttime (left: by Suomi-NPP/VIIRS/DNB), tricolor-10 m-nadir-single nighttime (centre; by aerial photography) and daytime (right; by Sentinel-2/MSI) images covering Berlin, Germany (credit: NOAA/GFZ/ESA/EU).

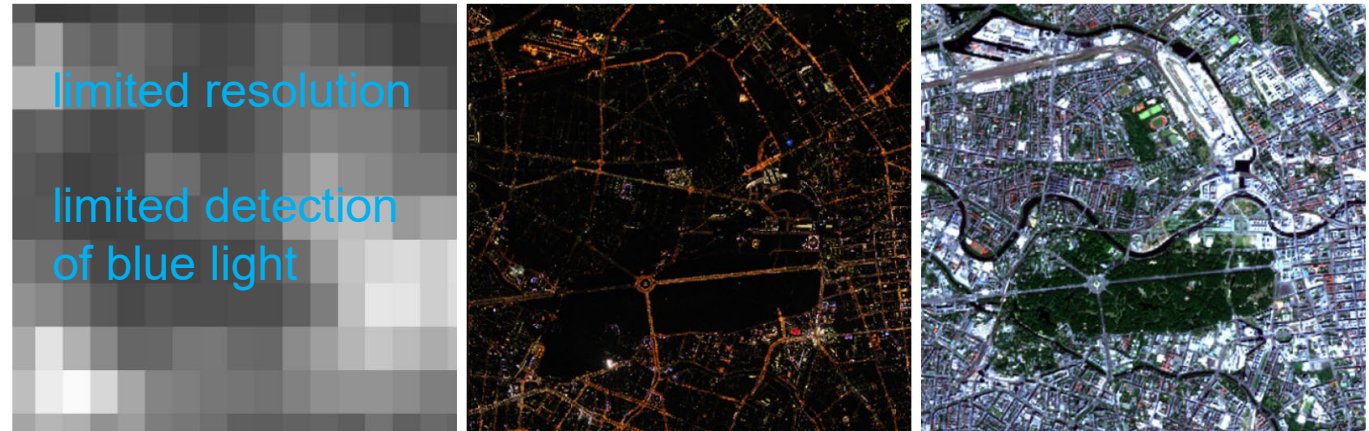
## Scientifically

- Quantify the global environmental effects of artificial nighttime lighting (ANTL)
- Focus on biological risks and opportunities
- “Mapping of [...] night-time artificial lighting [...] is a unique tool to globally monitor human presence and activity, and reveal changes [...] to study the impact [...] on human health and environment [...] needed with high spatial resolution at different times“\*

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- Influences of Artificial Light on Human Health and Well-Being
- Influences of Artificial Light on Animals and Plants
- Energy Consumption for Artificial Light
- Urbanisation, Electricity Access and Socio-Economy
- Identification of Hazards, Risks and Disasters and Monitoring of Conflicts
- Natural Properties of the Atmosphere and the Surface
- Cross-Calibration

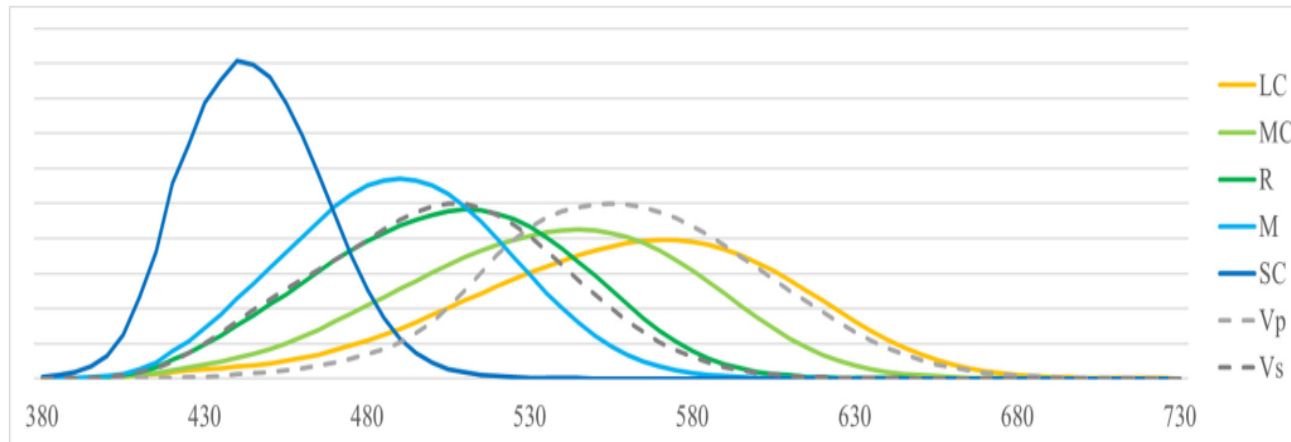


Pan-750 m-nadir-single nighttime (left: by Suomi-NPP/VIIRS/DNB), tricolor-10 m-nadir-single nighttime (centre; by aerial photography) and daytime (right; by Sentinel-2/MSI) images covering Berlin, Germany (credit: NOAA/GFZ/ESA/EU).

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Spectral sensitivity profiles of L-cone (LC), M-cone (MC), rod (R), melan (M) and S-cone (SC) opsins and photopic  $V_p$  and scotopic  $V_s$  visions (unit is nm).

- Influences of Artificial Light on Human Health and Well-Being

- Scientific Requirement

For each human populated area  $A$  (of size  $20 \text{ m} \times 20 \text{ m}$ ) the  $\alpha$ -opic radiances in the five human photoreceptor SC/Z/R/MC/LC, photopic  $V_p$  and scotopic  $V_s$  bands given by  $\int_{\lambda} L_{A,t,\lambda,\alpha} \text{SC/Z/R/MC/LC}/V_p/V_s(\lambda) d\lambda$  shall be estimated for nighttime with an accuracy of:  $\geq 80\%$  for view zenith angle  $0^\circ$  at  $\geq 4$  local times  $t$  for each quarter and for at least three years (measured);  $\geq 60\%$  (modelled)

effects associated with

- e.g. sleep quality, obesity, breast and prostate cancer risk
  - $\alpha$ -opic radiances in the five human photoreceptor bands
  - photopic and scotopic bands
  - melatonin suppression index and circadian stimulus index

- $SZA \geq 96^\circ$

Note: SZA is Sun Zenith Angle.

## Technically

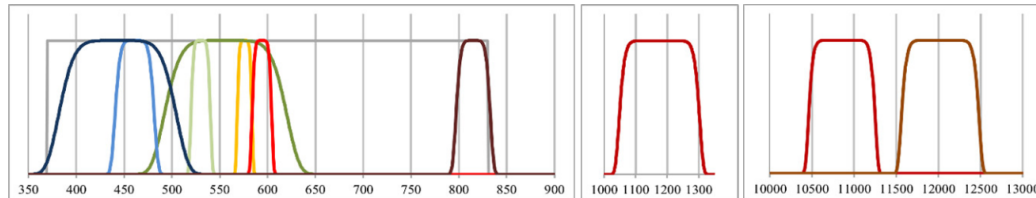
- Today not possible to evaluate and map associated biological risks and opportunities (as achieved for other anthropogenic pressures on the environment) for incorporation to policies addressing these pressures

- N8 creates and updates a globally consistent validated model of spectral ( $\lambda$ )-spatial ( $d, \alpha$ )-temporal ( $t$ ) dynamics artificial nighttime lighting based on

- global ( $-56^\circ$  S to  $+72^\circ$  N)
- multi-spectral (8 VIS/NIR)
- high-resolution (20 m)
- multi-angular (3 views)
- frequent (10 days, changing local times)

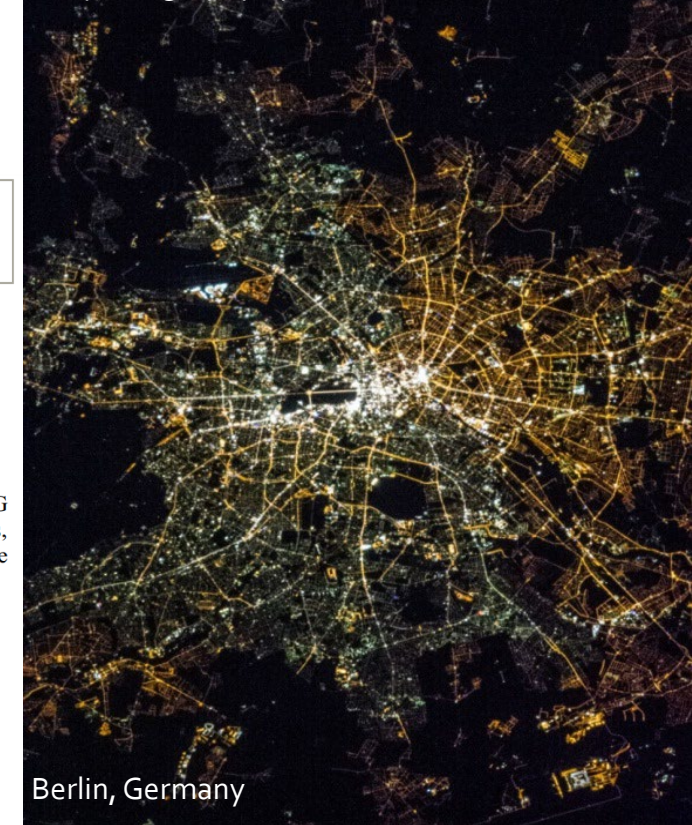
optical remote sensing nighttime light data

All land surfaces and inland water bodies between latitudes  $-82^\circ$  S and  $+82^\circ$  N (G) /  $-56^\circ$  S and  $+72^\circ$  N (L) with areas greater than  $100 \text{ km}^2$  and coastal zones within 20 km distance from land shall be acquired (area-of-interest).



PAN: radiant flux. Broad green: luminous flux, photopic band. Broad blue: scotopic band, spectral G index. VIS/NIR: classification of lighting technology, correlated colour temperature, in-band radiances (humans, plants, other animals). SWIR: high accuracy for incandescent bulb, temperature. LWIR: temperature, atmosphere with total water vapour (unit is nm).

ISS/photography by astronaut



Berlin, Germany



Acquisitions shall be performed with  $SZA \geq 96^\circ$  (night) and moon illumination shall be

•  $SZA \geq 96^\circ$

Note: SZA is Sun Zenith Angle.

# Technically

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- N8 creates and updates a globally consistent validated model of spectral ( $\lambda$ )-spatial (d, $\alpha$ )-temporal (t) dynamics artificial nighttime lighting based on

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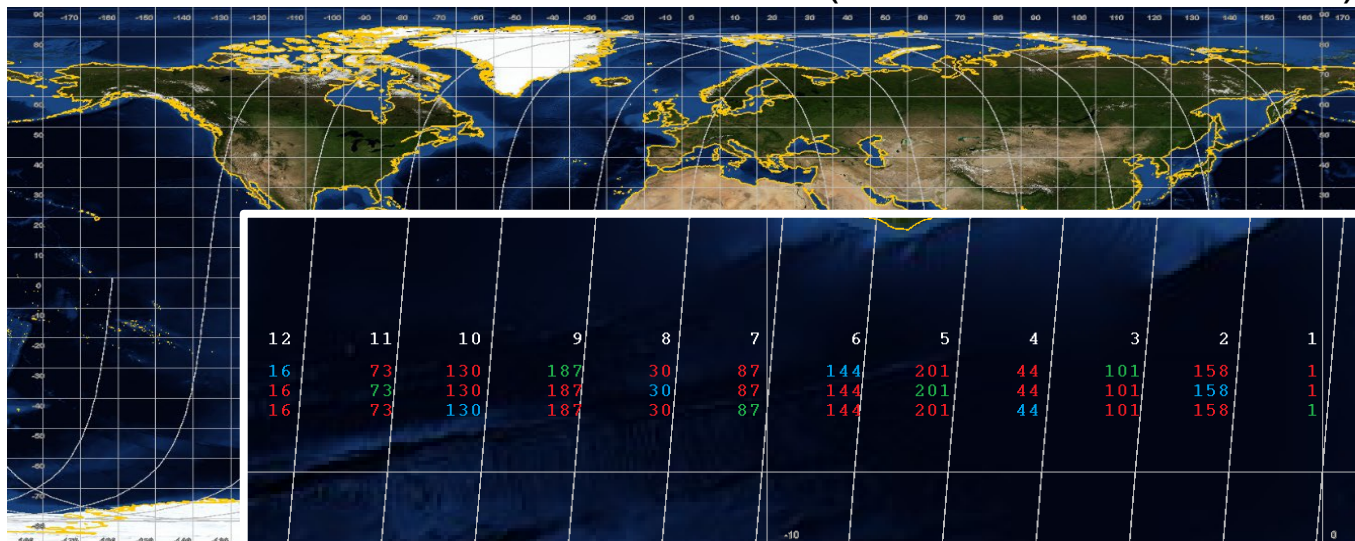
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Acquisitions shall be performed with  $VZA \leq 15^\circ$ .

• **nadir view**  
Acquisitions shall be performed  $\geq 2$  with  $75^\circ \leq VAA \leq 105^\circ$  and for the same area the same VZA between  $45^\circ$  and  $2^\circ$  less than limb view.

• **max along and max across view**  
Note: VZA is View Zenith Angle (between view and surface).

- 214 orbits in 15 d with drift -480 sec/d (= -2 h/15 d = -12 h/90 d)



- Ground tracks separation: 188 km
- Across track swath: 284 km with 2x nadir, 1x along, 2x nadir, 1x across, ...

• 90 d with 2 h intervals, change in night and in year



## Modifications, e.g.

- Quantify ~~the~~ global environmental effects of artificial nighttime lighting (ANTL)
- Focus on urbanisation and electricity access
- create consistent maps of ANTL based on
  - urban centers (and clusters)
  - multi-spectral (4 VIS/NIR)
  - high-resolution (~5 m)
  - multi-angular (~3 views)
  - regular (~90 days, changing local times)
 optical remote sensing NTL data
- would result in small satellite mission, e.g. using frame camera

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## 1<sup>st</sup> European Workshop on Artificial Nighttime Light Remote Sensing

Noordwijk (The Netherlands) 30 March - 1 April 2022



# Thanks!

- `tobias.storch@dlr.de`