

**Research and development in the field of
measurement and evaluation of artificial
light in the night environment and its
impact on living organisms and the
environment as a whole**

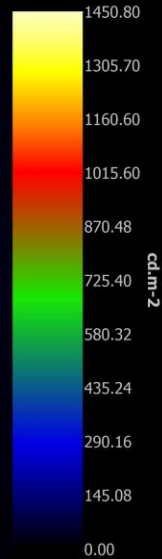
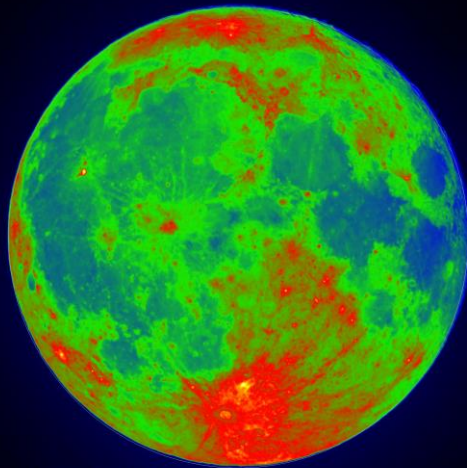
Assoc. Prof. Ing. Petr Baxant, Ph.D.

Ing. Filip Novák

Faculty of Electrical Engineering and Communication
Department of Electrical Power Engineering

Natural light as standard

LDA - LumiDISP | Brno University of Technology



Date, Time: 04.07.2023 00:19:15
GPS:49.2028511N, 16.6674106E (Brno, CZ)
Alt.: 12.9° | Az.: 177,7° (N of E)
Lavg = 682.3 cd.m-2 | Lmax = 1450.8 cd.m-2

In the night environment, the **Moon** can be considered the brightest object of the natural origin.

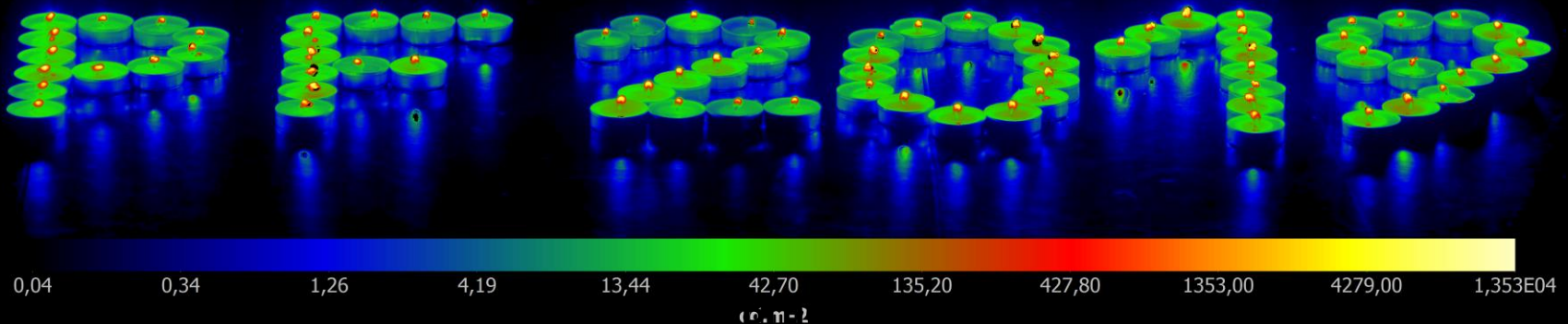
The luminance of the **Moon** changes with position and at full moon we can measure an average value of eg. 3500 candela per square meter (cd.m^{-2}).

At a distance of the Moon on average 384.000 km this cosmic object will create an illumination lower than **0,25 luxes (lx)** on the Earth's surface. This is the reflected light of the Sun.

Compare: sunny day 100 000 lx = 400 thousand times higher surface illumination than night at the full moon.

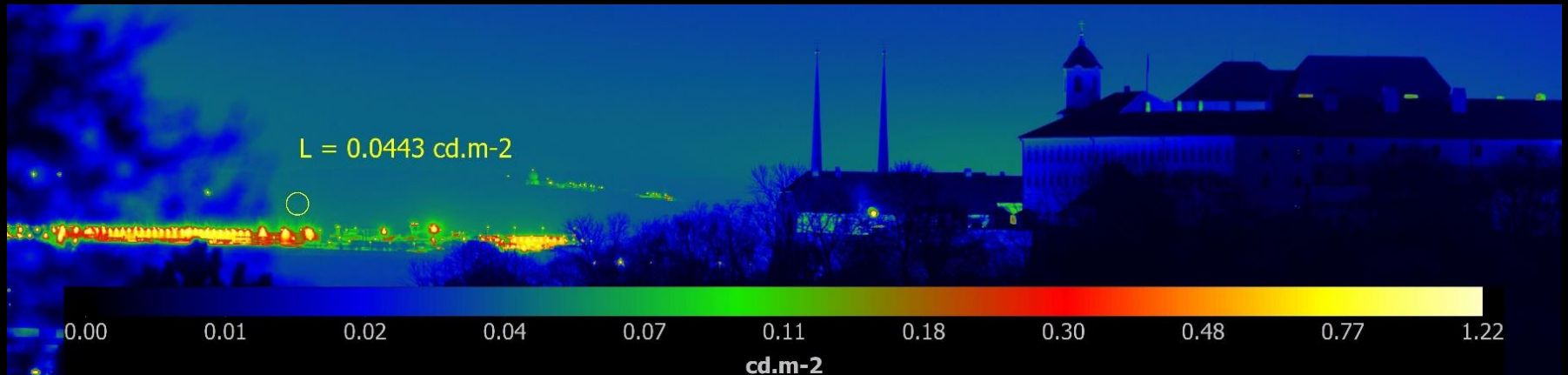
The natural night is very dark compared to the time of day.
In the time between full moons, these are ratios greater than **1:1 000 000!**

The **flame of the candle** has a luminance approximately the same as the surface of the **Moon**, the maximum range up to 13,500 candelas per square meter. However, the light intensity of one candle is 30 billion times less than the light intensity of the entire **Moon** (30,000,000,000,000 times, approximately).



Natural light as standard

The **yellow circle below** has a luminance approximately 50 000x smaller than the surface of the **Moon**. However, we see the Moon with solid angle of approximately $6.4 \cdot 10^{-5}$ sr, while the (night) **sky** can be seen with solid angle of 2π sr – almost 100 000x more.



Our approach

- Almost all methods of light pollution measurement are based on **luminance** measurement of the night sky. We work to extend the measurement to the **melanopic domain** and quantities.
- The results from these measurements are useful, but mainly for astronomers – they do not tell us anything about the sources of the LP. The values of luminances also fluctuate based on the weather = more clouds and/or snow means more skyglow.
- Also the skyglow isn't typically what causes the most damage to the environment – **direct exposure to the artificial light is**.
- Therefore we need to be able to analyse the sources of LP directly where they are installed.
- We measure the luminance values of the Sun and Moon to better understand the propagation and extinction of artificial light in the atmosphere.
- Those results will be used to create a **database of luminances values** for a wide range of cases (different position of the celestial body on the sky, different weather...)
- Luminance analysers are being used for both measuring skyglow and direct measurement of sources of LP

Global participation

We have attended conferences and workshops with global impact, including the 30th Quadrennial Session of CIE in Ljubljana and the ALAN 2023 conference in Calgary. We will attend the Meeting on Light Pollution in Granada, ES this November.

What are the current trends in ALAN research?

ALAN is being studied not only from the **photometrical** or **astronomical** point of view

- Impact of ALAN on different species (Nightjars, Eel, trout, bats, insect...)
- Social and cultural impact of ALAN (e.g. Heim (2023) or Sam (2023))
- Usage of inexpensive, simple sensors (or smartphones)
- More and more complex models (Monte Carlo and more)

Most notable articles in the past year

PUSCHING, J., Wallner, S. : A decade of SQM light pollution measurements in Austria

WALCZAK et al., Identifying Sources of Sky Glow Through Triangulation with a Distributed All-Sky Camera Survey

JECHOW et al., Towards a new reference for ecologically dark skies: pan-continental all-sky measurements of overcast skies at places (almost) free of ALAN

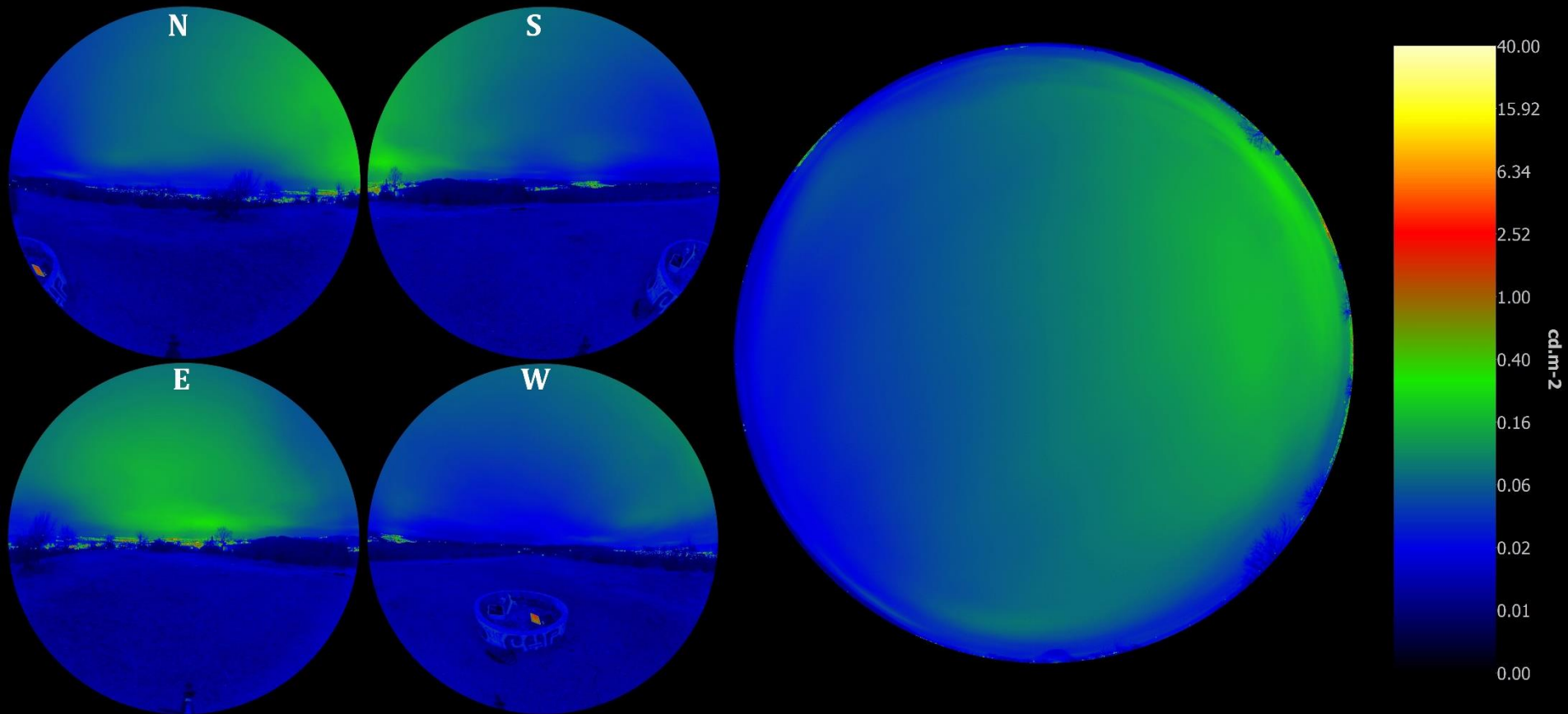
Ongoing research

Usage of a luminances analyzer equipped on a motorised mount



Ongoing research

From this...



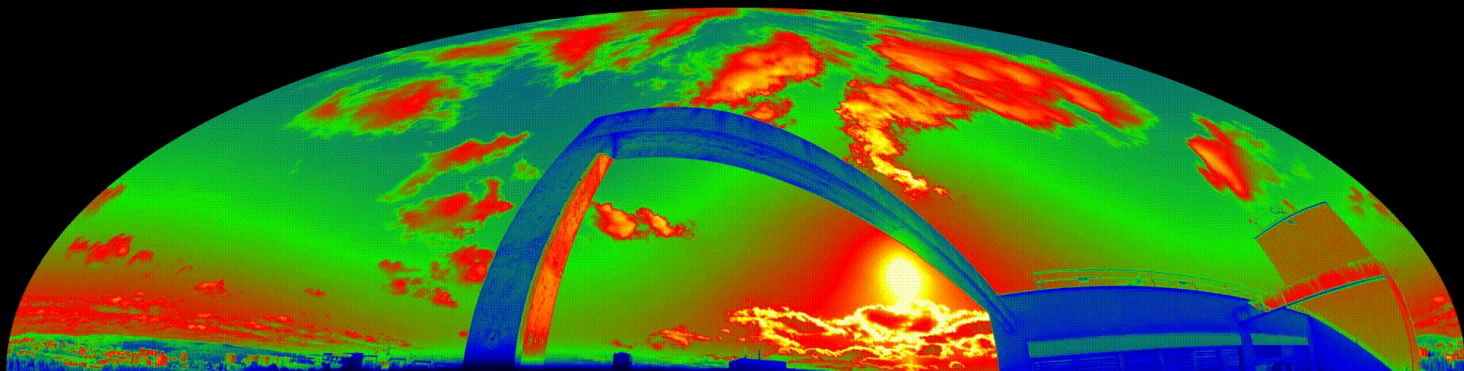
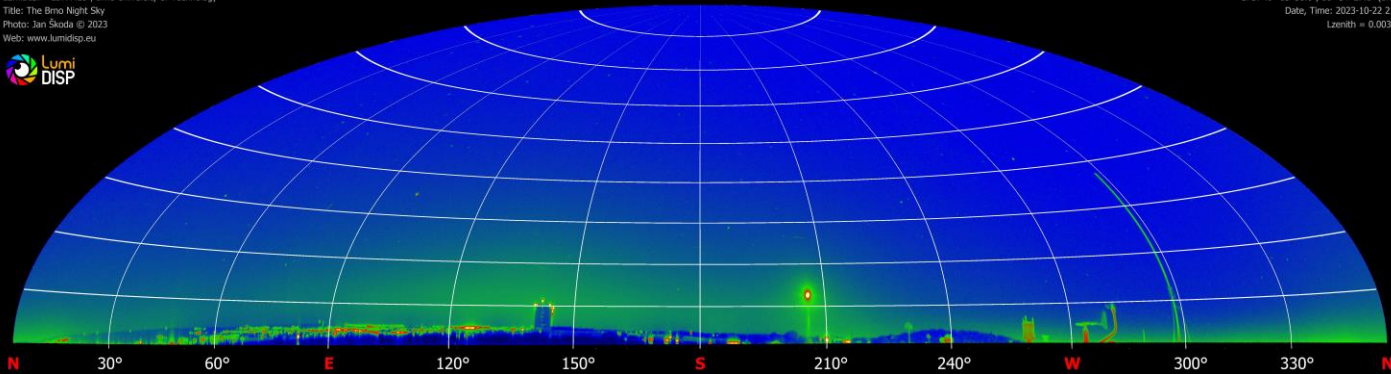
Ongoing research

...to this...

LumiDISP - LDA ML6 | Brno University of Technology
Title: The Brno Night Sky
Photo: Jan Škoda © 2023
Web: www.lumidisp.eu



GPS: 49° 13' 38.0", 16° 34' 27.1" (Brno, CZE)
Date, Time: 2023-10-22 21:41:30
Zenith = 0.003 cd.m⁻²

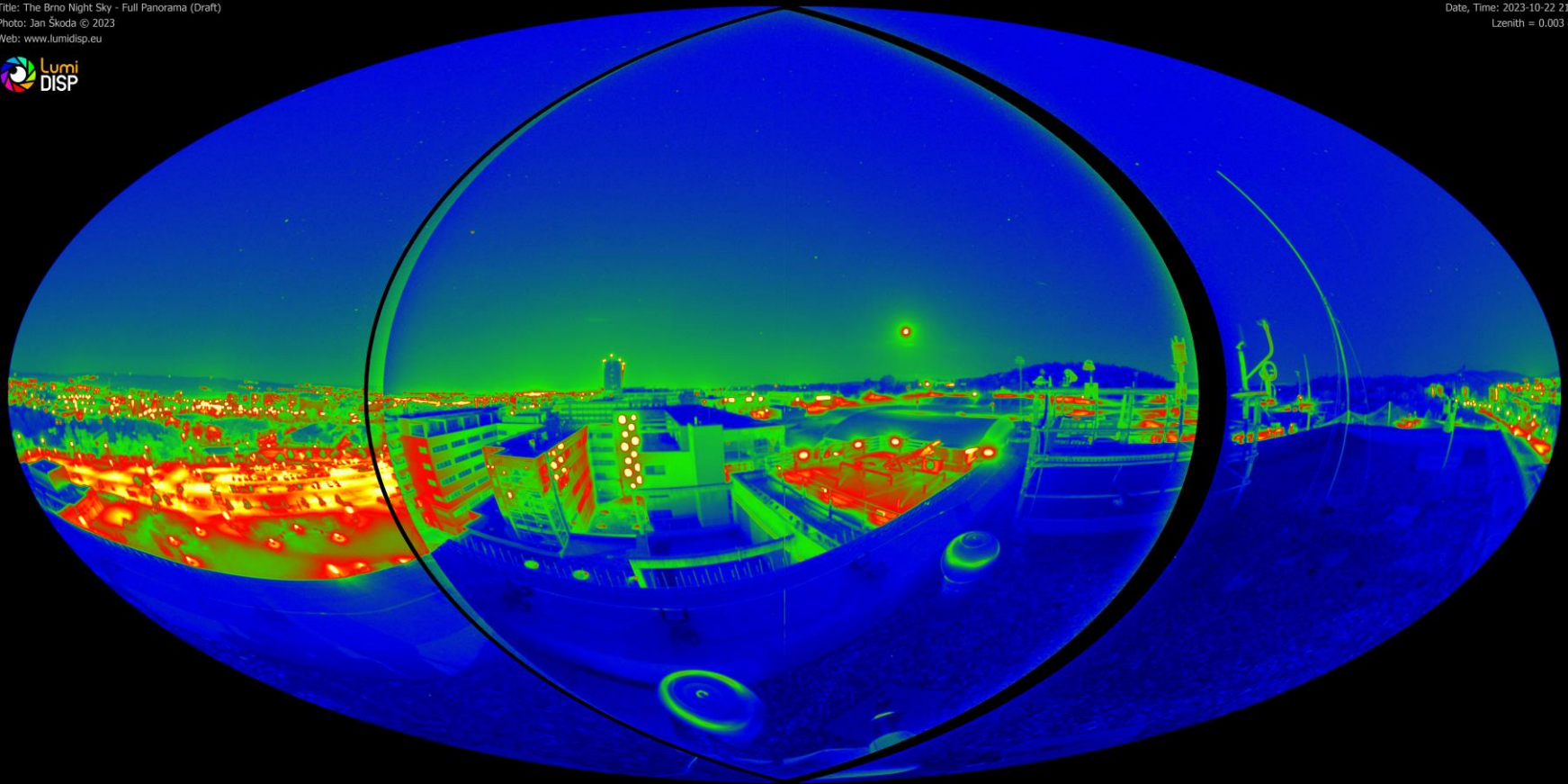


Ongoing research

...or this

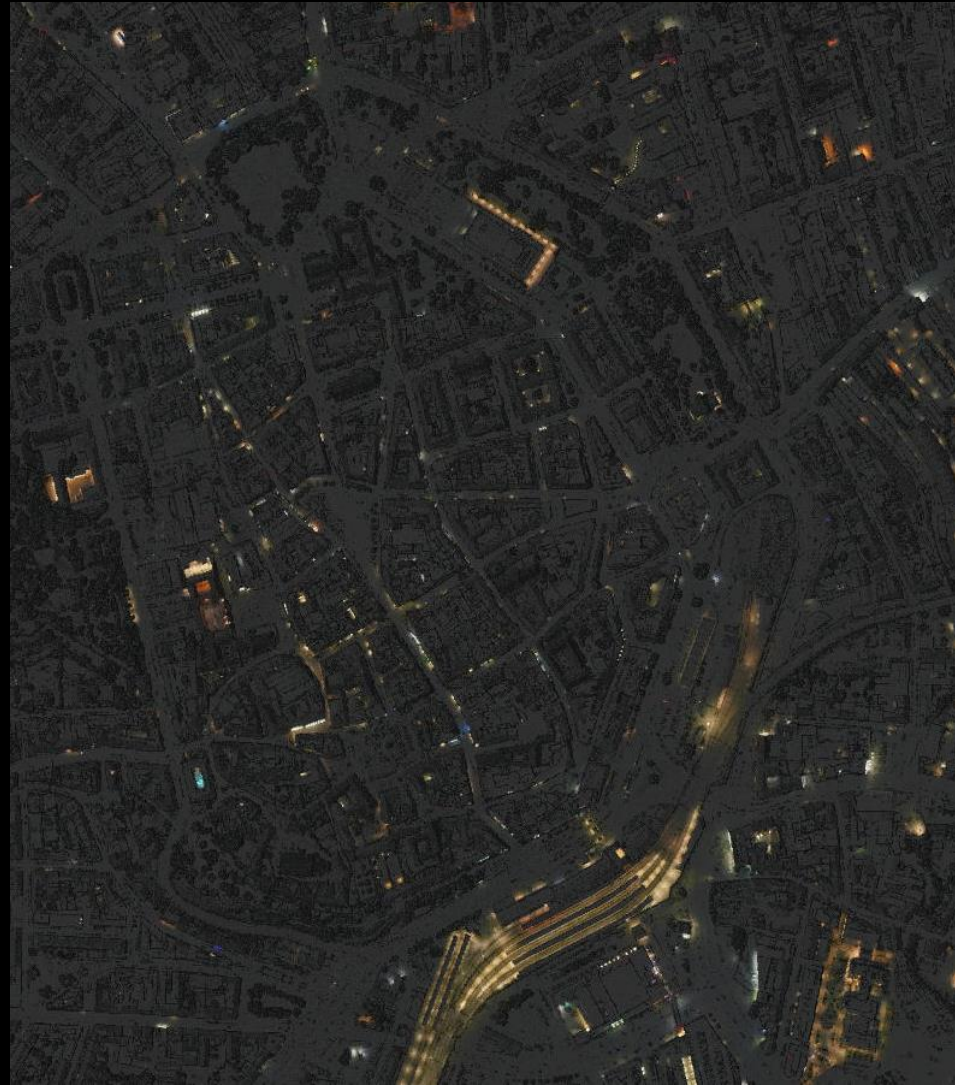
LumiDISP - LDA ML6 | Brno University of Technology
Title: The Brno Night Sky - Full Panorama (Draft)
Photo: Jan Škoda © 2023
Web: www.lumidisp.eu

GPS: 49° 13' 38.0", 16° 34' 27.1" (Brno, CZE)
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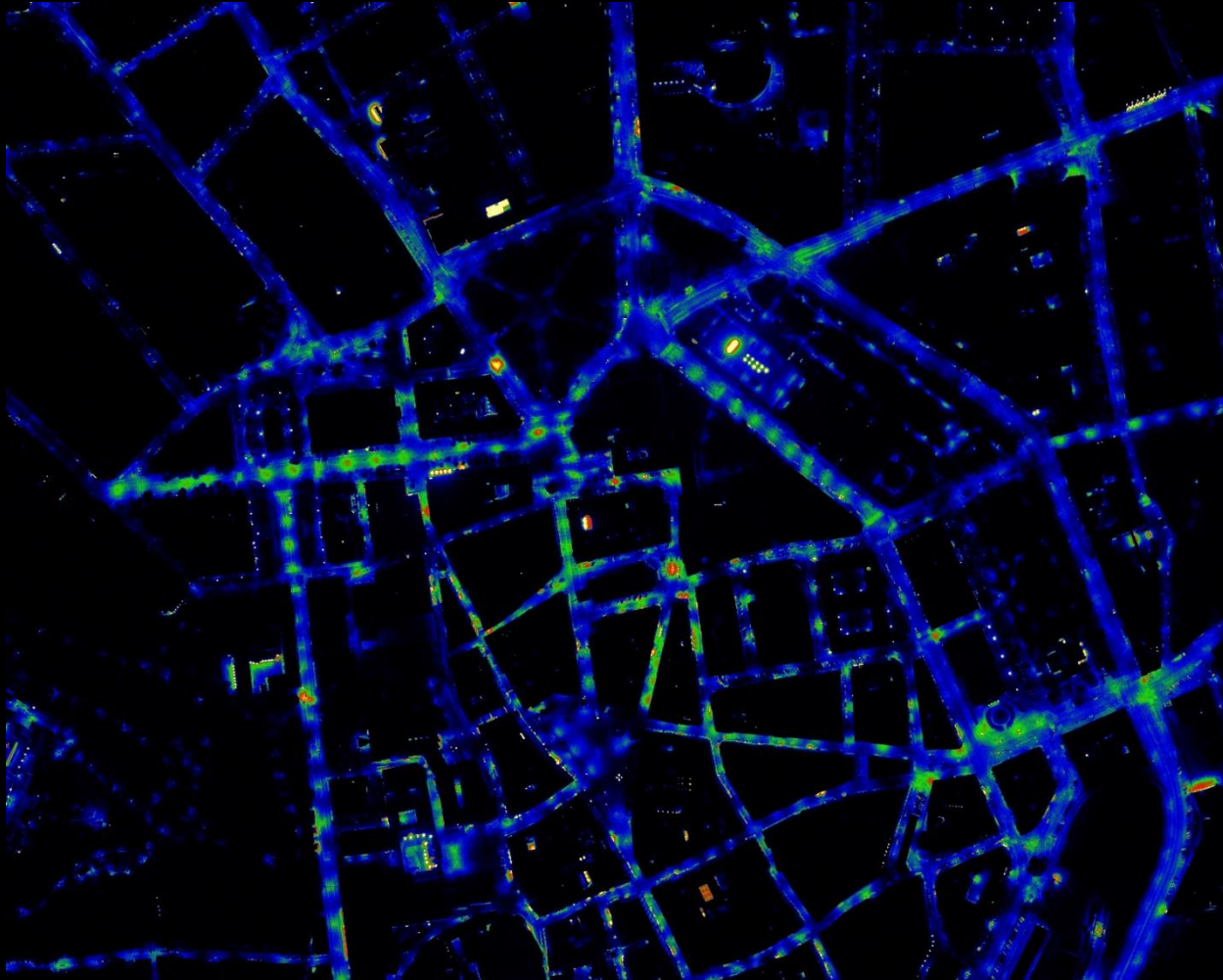
Ongoing research

Usage of aerial pictures to quantify the impact of ALAN



Ongoing research

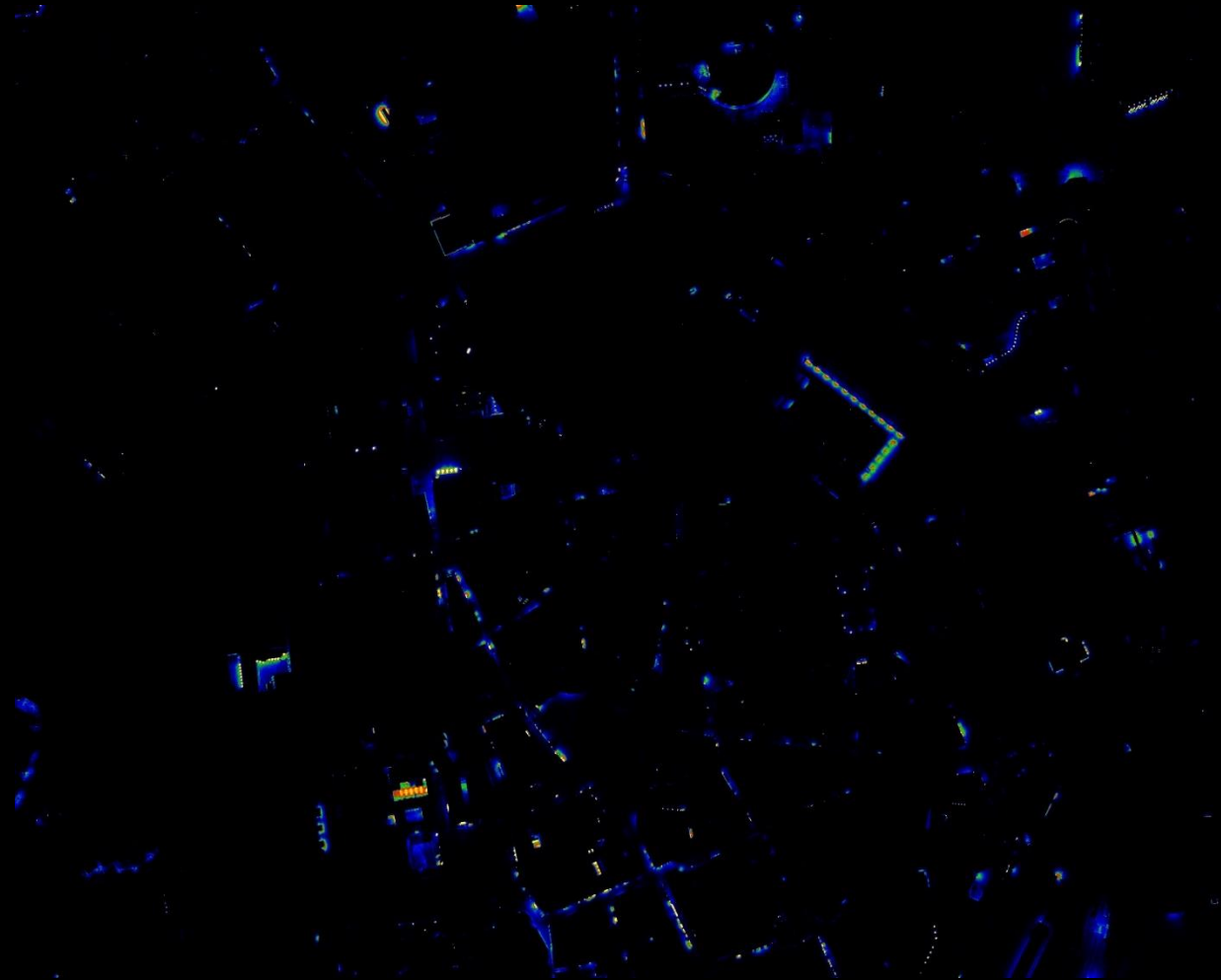
Usage of aerial pictures to quantify the impact of ALAN – Brno city centre



Public lighting ON

Ongoing research

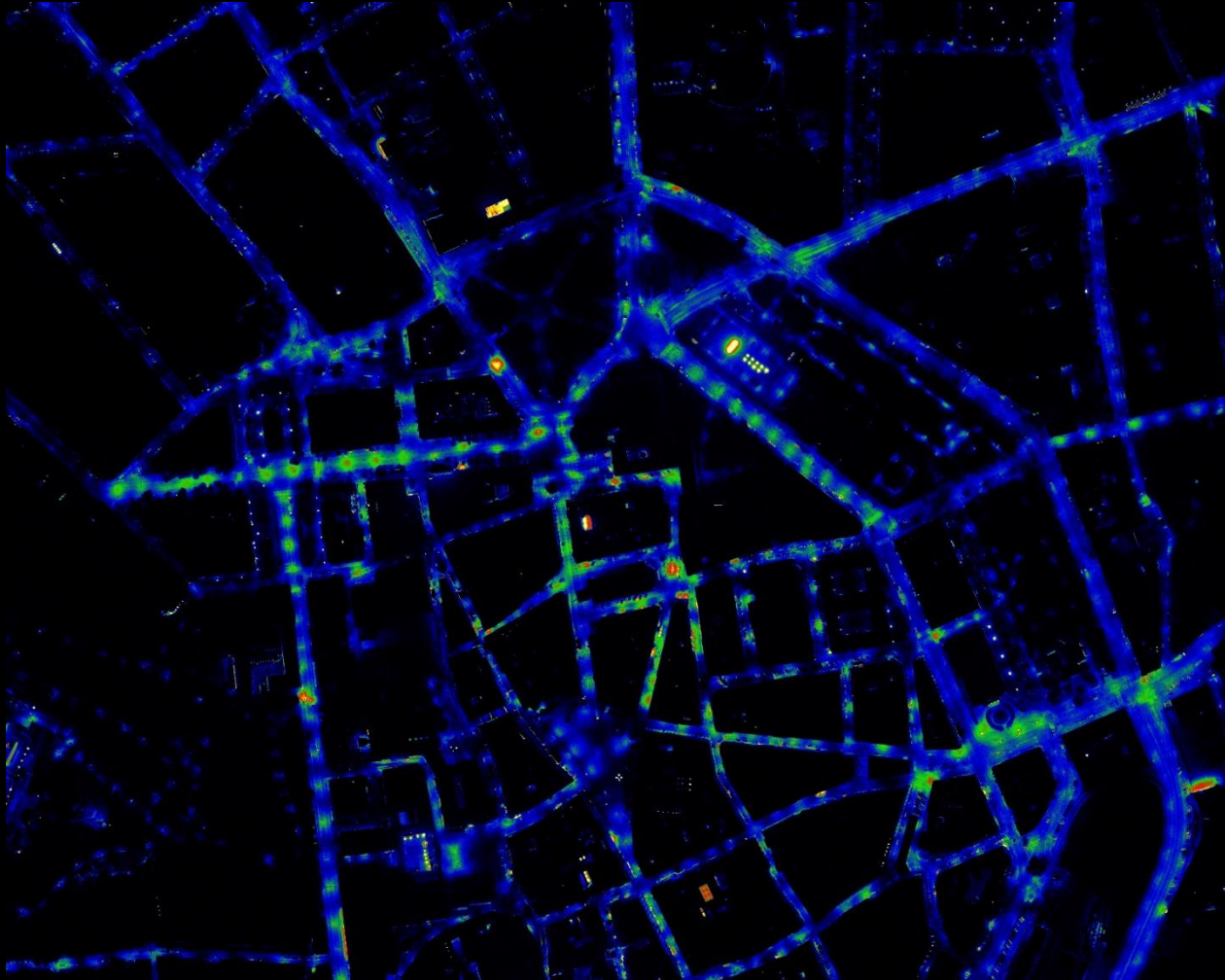
Usage of aerial pictures to quantify the impact of ALAN – Brno city centre



Public lighting OFF

Ongoing research

Usage of aerial pictures to quantify the impact of ALAN – Brno city centre

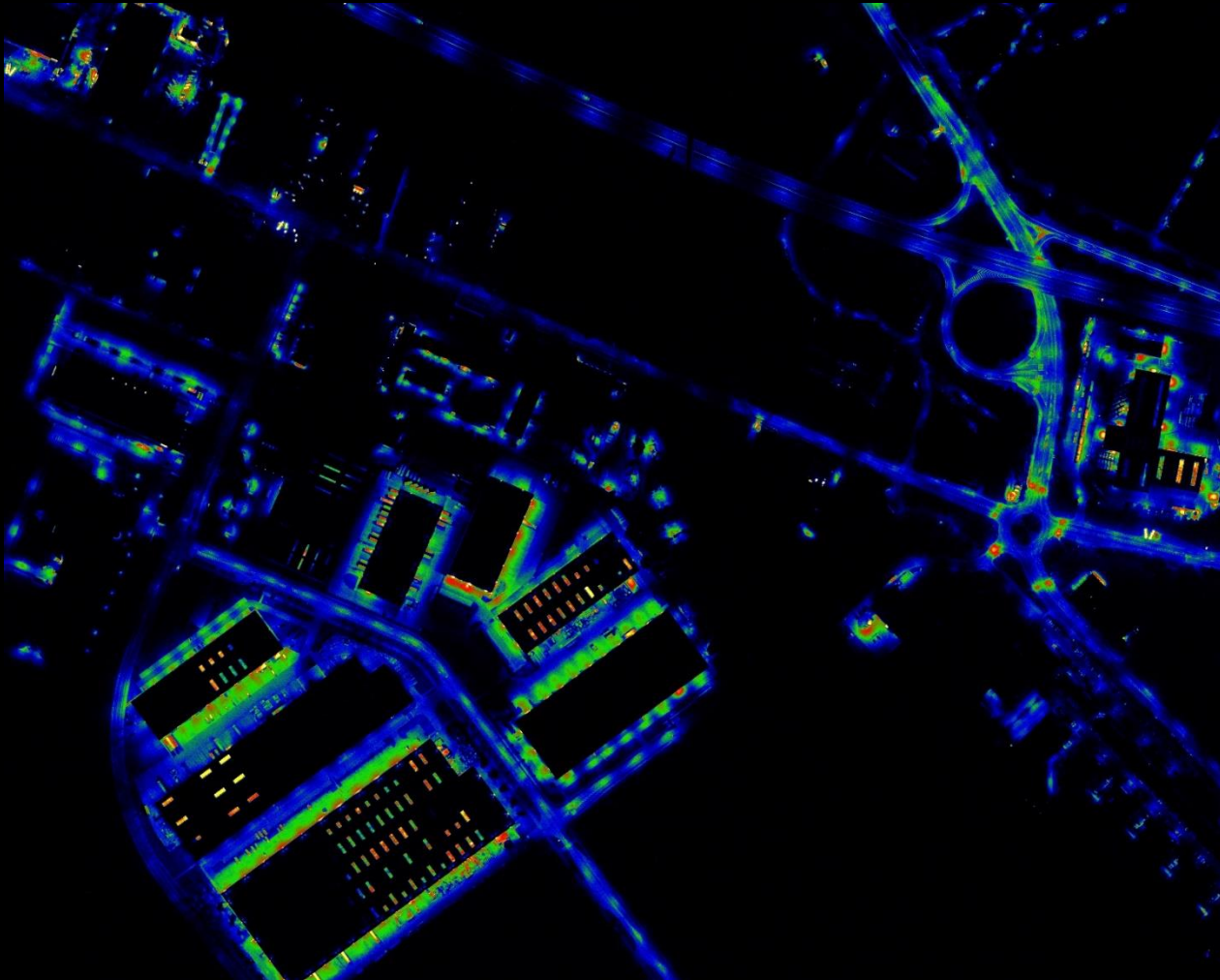


The difference between **ON** and **OFF**

$\delta L = 85,1 \%$

Ongoing research

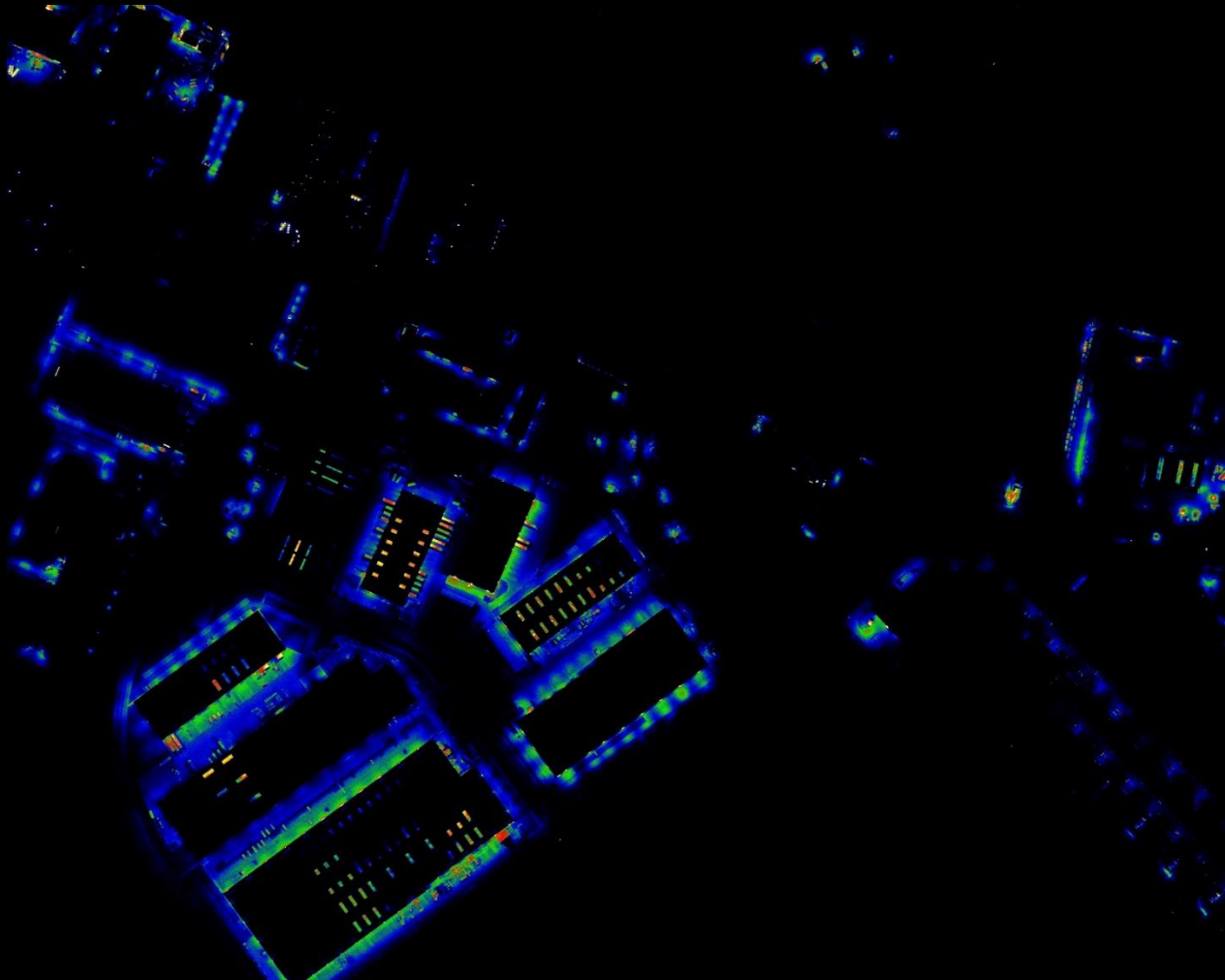
Usage of aerial pictures to quantify the impact of ALAN – Industrial area of Brno



Public lighting ON

Ongoing research

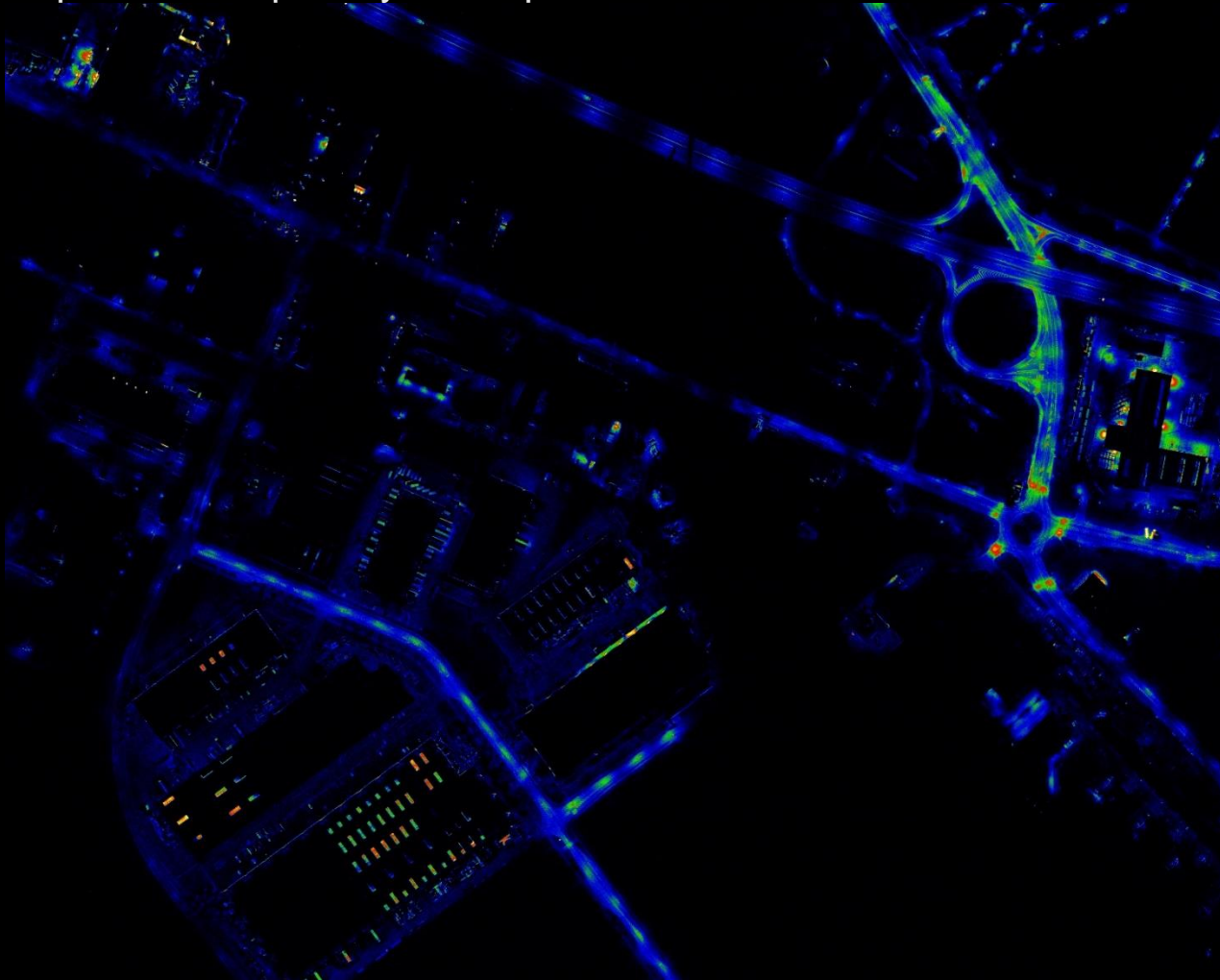
Usage of aerial pictures to quantify the impact of ALAN – Industrial area of Brno



Public lighting OFF

Ongoing research

Usage of aerial pictures to quantify the impact of ALAN – Industrial area of Brno

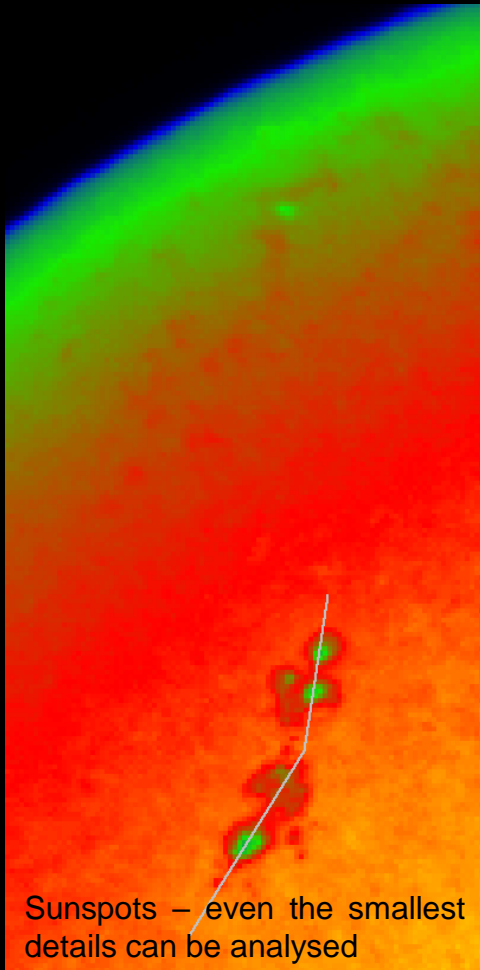


The difference between **ON** and **OFF**

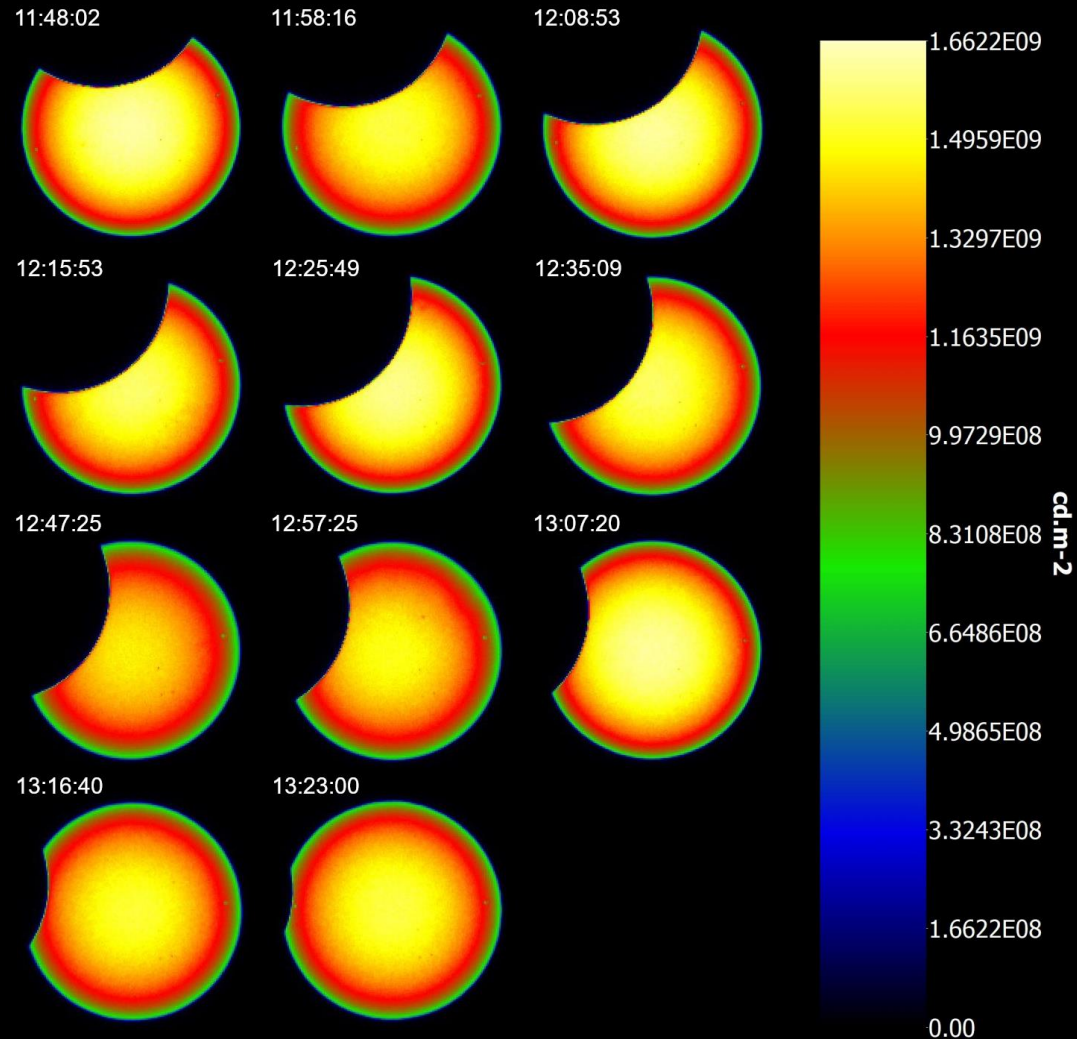
$\delta L = 41,5 \%$

Ongoing research

Luminance analysis of the Sun



Solar eclipse on 25th of October, 2022

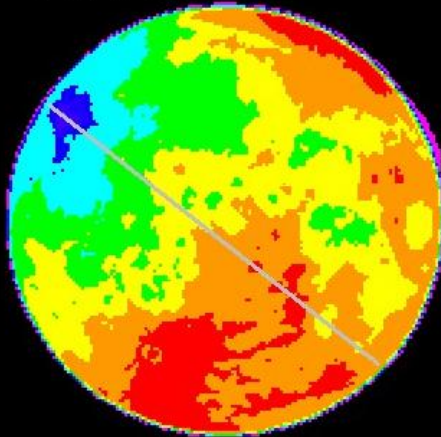


Ongoing research

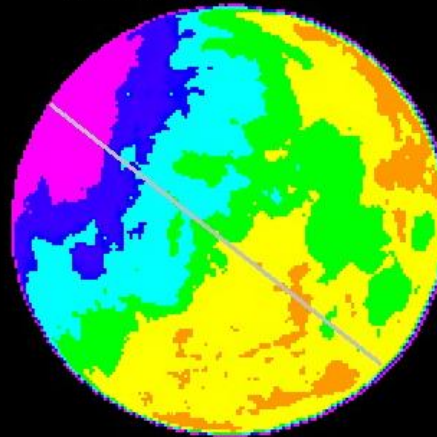
Luminance analysis of the Moon

Lunar eclipse on 16th of May, 2022

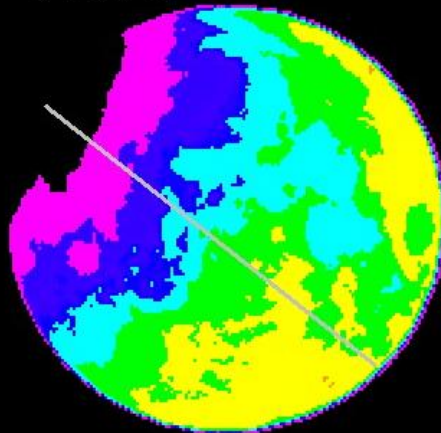
04:11:33



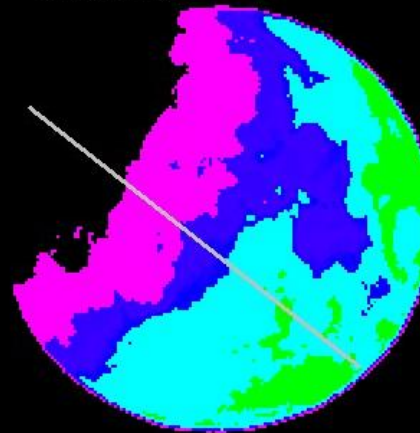
04:21:01



04:25:45



04:31:40



Luminance
zoning

Conclusion

- Measuring just the luminances values of the night sky is not quite enough for precise light pollution analysis, we need to also measure the sources of LP in situ.
- Motorised mounts for the measuring equipment can help quite a bit, they speed up the measurement and also make analysis of the results more convenient.
- The Sun, the Moon (and possibly other celestial bodies) can be used as a sort of photometric standards, which in turn helps to understand the current state of atmosphere.
- Aerial photography can be very well used to quantify sources of light pollution, but it is not cheap and convenient enough to use in most cases.
- We are still looking for the optimal way to measure and analyse artificial light at night, but there has been also some promising progress.
- Our mission is to provide scientists with objective data about the light at night, and not only in a visual spectrum.

People and contacts

Research and development of luminance measurements is currently handled by the workplace of the Department of Electrical Power Engineering and the lighting technology laboratory.



Leader and guarantee of the project
Assoc. Prof. Ing. Petr Baxant, Ph.D.



Hardware platform and calibration
Ing. Jan Škoda, Ph.D.



Measurement uncertainty
Ing. Martin Motyčka, Ph.D.



ALAN research
Ing. Filip Novák



Software platform
Ing. Stanislav Sumec, Ph.D.



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The data in the presentation cannot be taken as a scientific basis in this form. They cannot be interpreted in this form and taken over into any other materials without the agree of the authors.

The development of measuring methods and devices takes place in the Center for Research and Utilization of Renewable Energy Sources (CVVOZE). The authors thank the Ministry of Education, Youth and Sports for financial support from the SS05010159 program.

Special thanks

Authors specially thank to the following partners, who realize and help the switch off the public lighting for the experiment in Brno city to obtain this crucial data



Brno City Municipality



Technical Networks Brno

