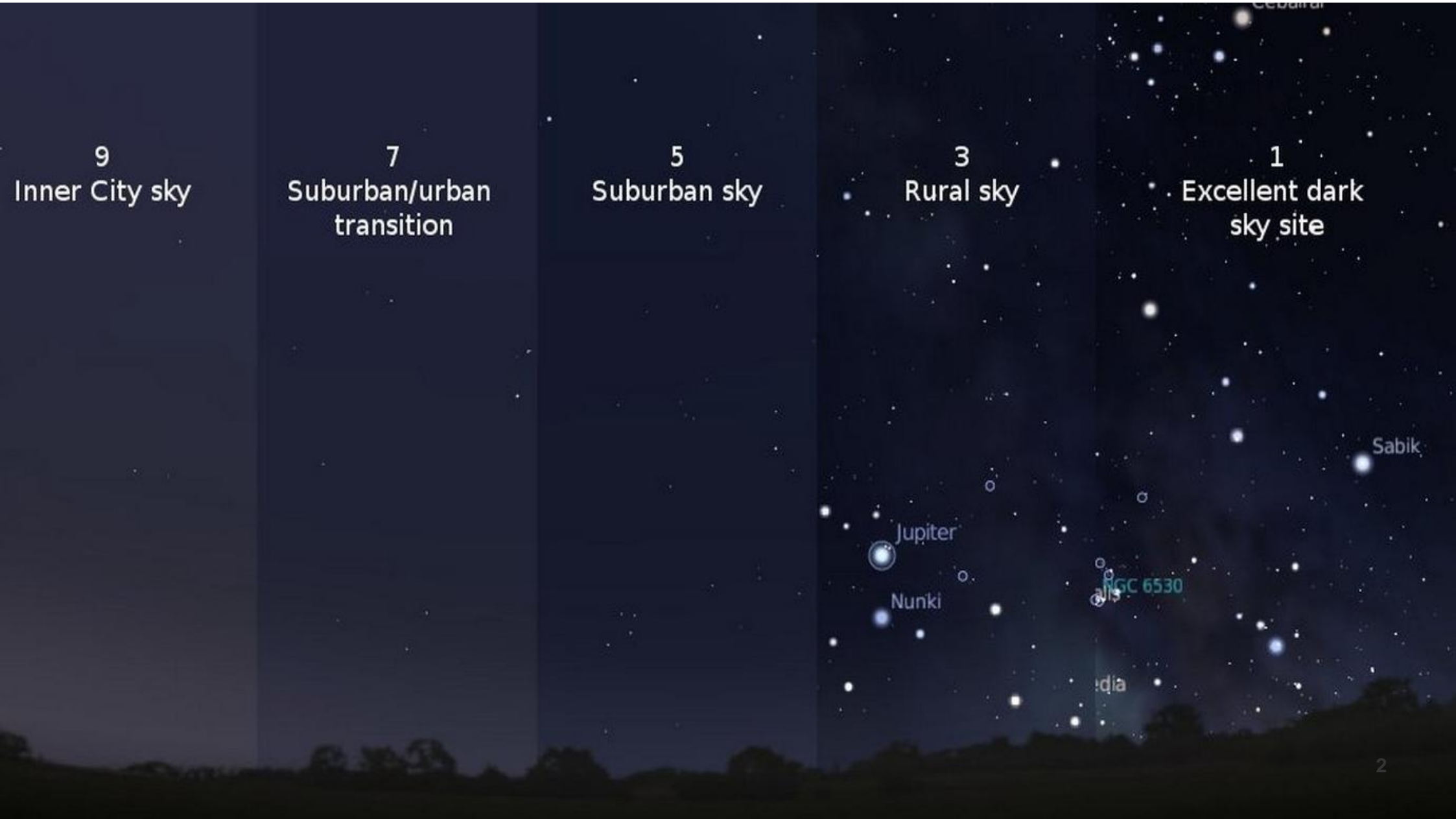


Health effects associated with remotely sensed night-time lights

Antti Petteri Hiltunen
University of Eastern Finland
Department of Geographical and Historical Studies



9

Inner City sky

7

Suburban/urban
transition

5

Suburban sky

3

Rural sky

1

Excellent dark
sky site

Jupiter

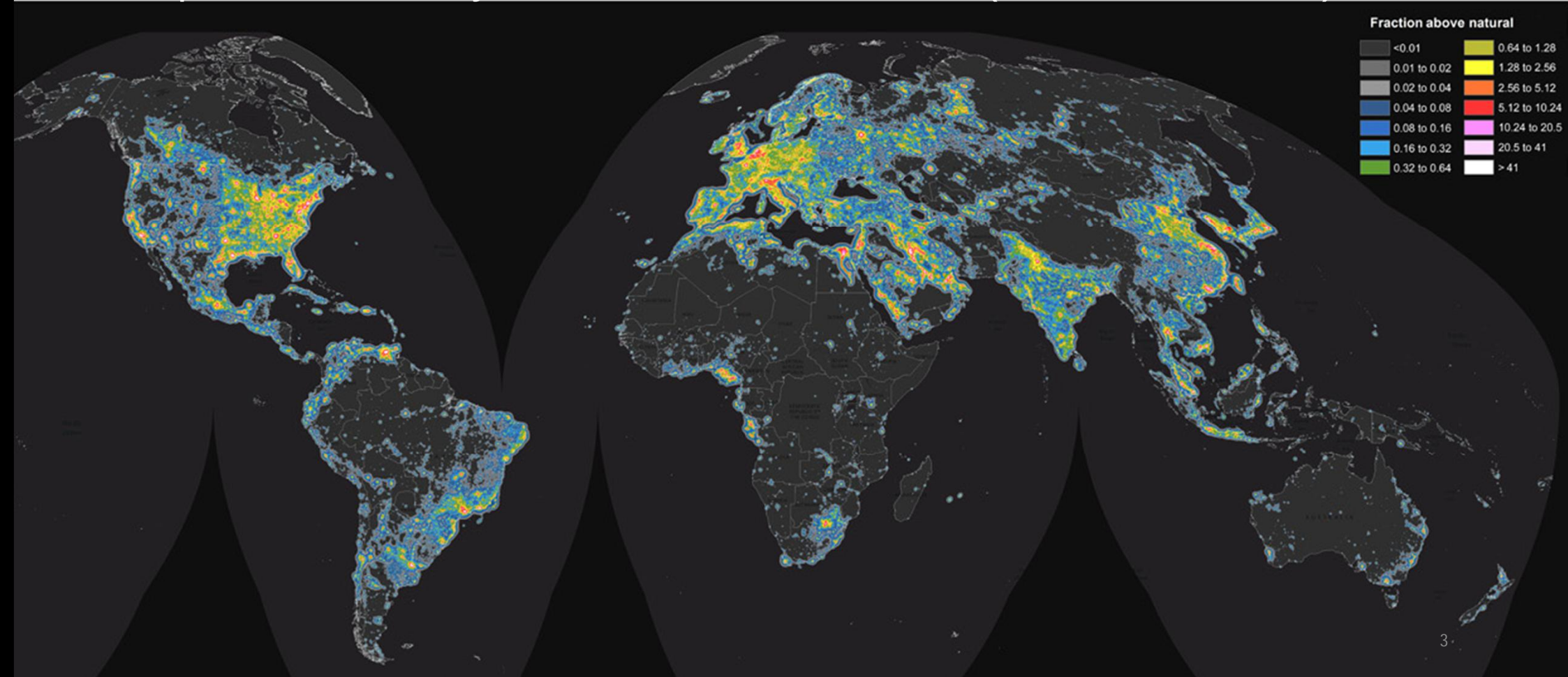
Nunki

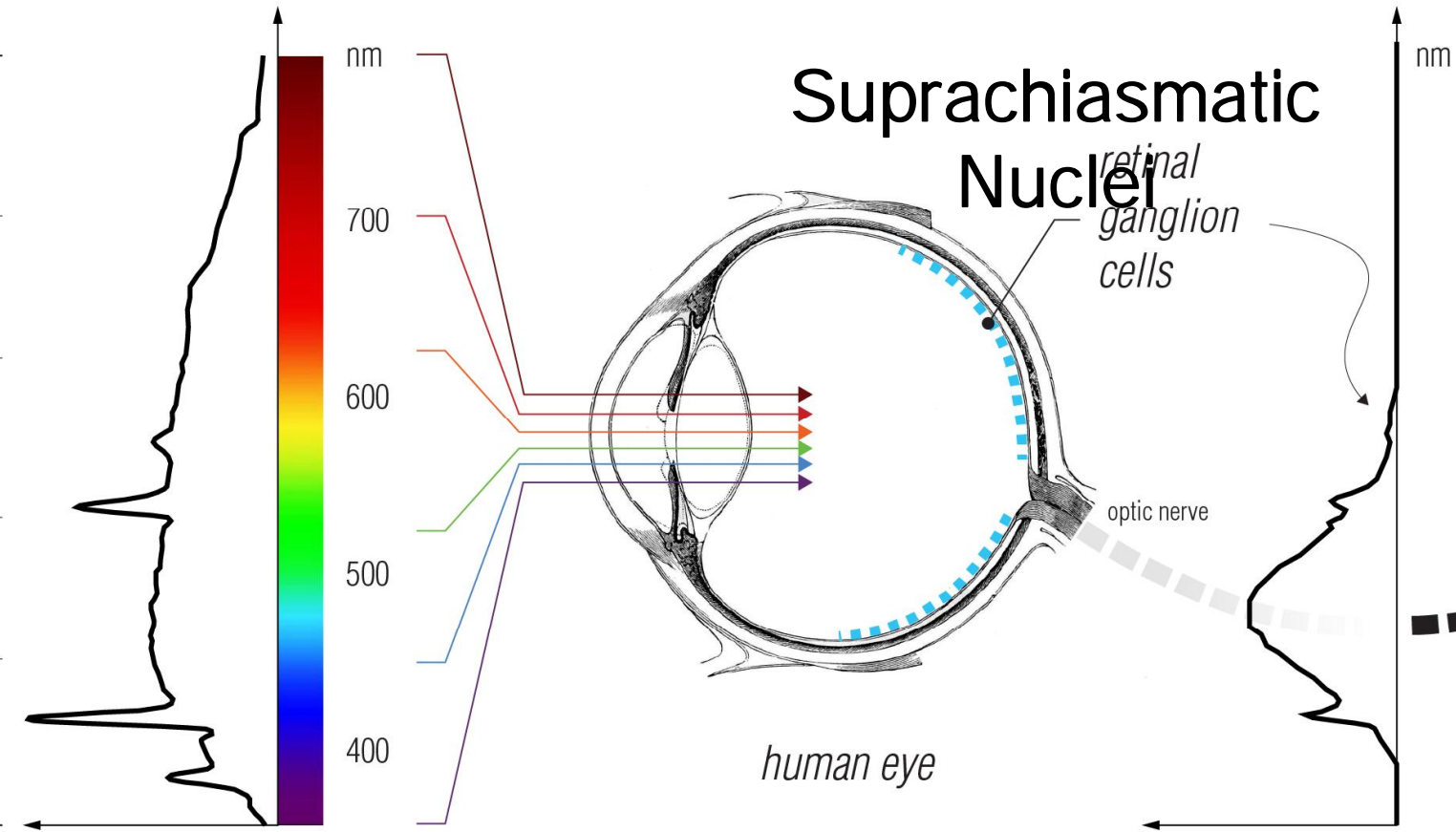
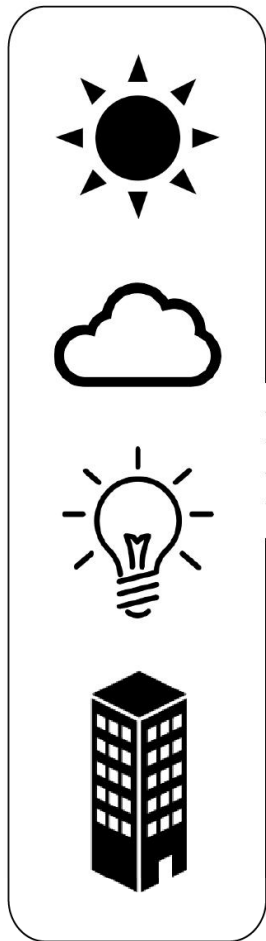
Sabik

NGC 6530

edra

“This atlas shows that more than 80% of the world and more than 99% of the U.S. and European populations live under light-polluted skies. The Milky Way is hidden from more than one-third of humanity, including 60% of Europeans and nearly 80% of North Americans.” (Falchi et al. 2016.)





incoming light spectrum

= Intrinsically Photosensitive Retinal Ganglion Cells
ipRGC photoreception (blue sensitive)

DAYTIME ELECTRIC LIGHT

BENEFITS

- Increased alertness
- Increased vigilance
- Increased productivity
- Sleep improved
- Mood improved
- Health improved

NOCTURNAL ELECTRIC LIGHT

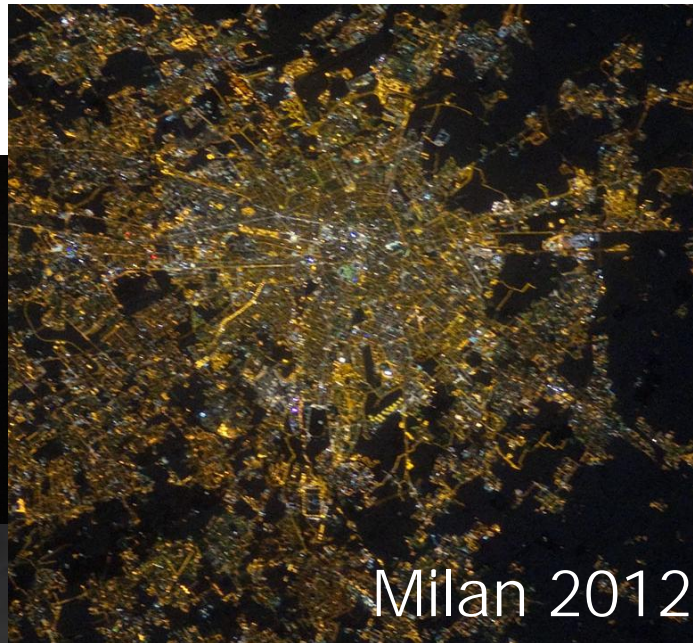
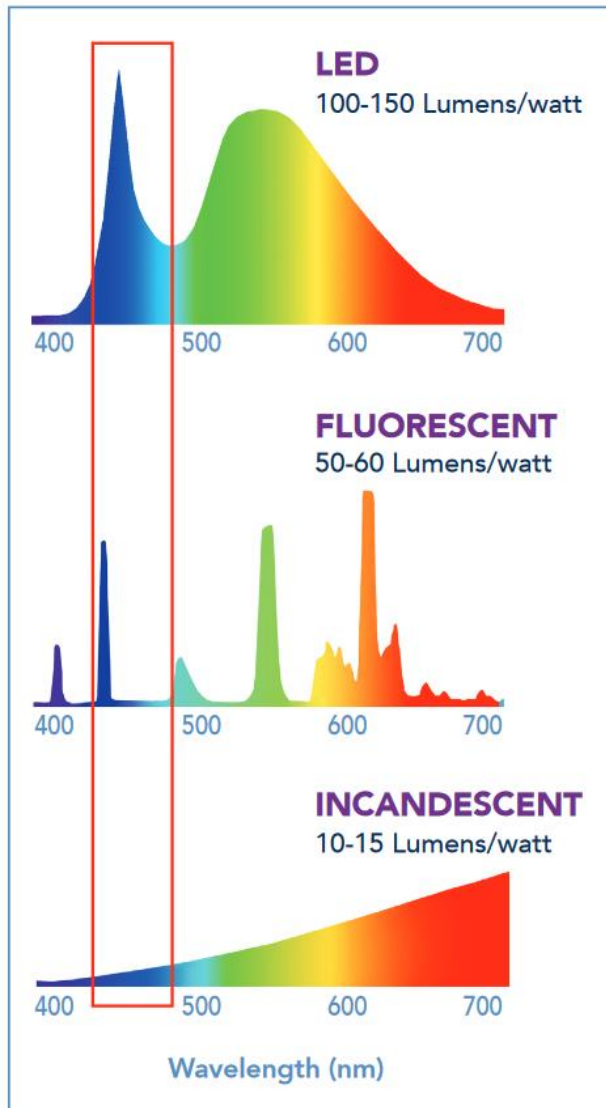
COSTS

- Sleep disruption
- Breast/prostate/colon cancers
- Obesity/diabetes Type 2 metabolic syndrome
- Cardiovascular disease
- Depression/Mood disorders

Blue light is beneficial during daytime, increasing alertness and productivity while improving health and mood by activating the biological clock

On the other hand light-at-night, especially blue light, disrupts circadian rhythm, suppresses melatonin production, affects metabolism, increases insulin resistance and glucose tolerance. This can increase the risk of hormonal cancers, obesity, type 2 diabetes (T2D), bowel diseases and mood disorders.

Harmful blue light might increase in the future with LED technology



Photos from International Space Station show that conversion to white LED lights can increase the blue light in our environment. This can result as an increase in health risks and health care expenses in the long run.

What kind of outdoor lights should be preferred?

According to American Medical Association, 3000K Correlated color temperature (CCT) LED lights should be preferred over higher color temperatures (>4000K). High color temperature lights contain more blue light and can thus increase health risks, glare, discomfort and ecological impacts.



Existing 2200 Kelvin HPS

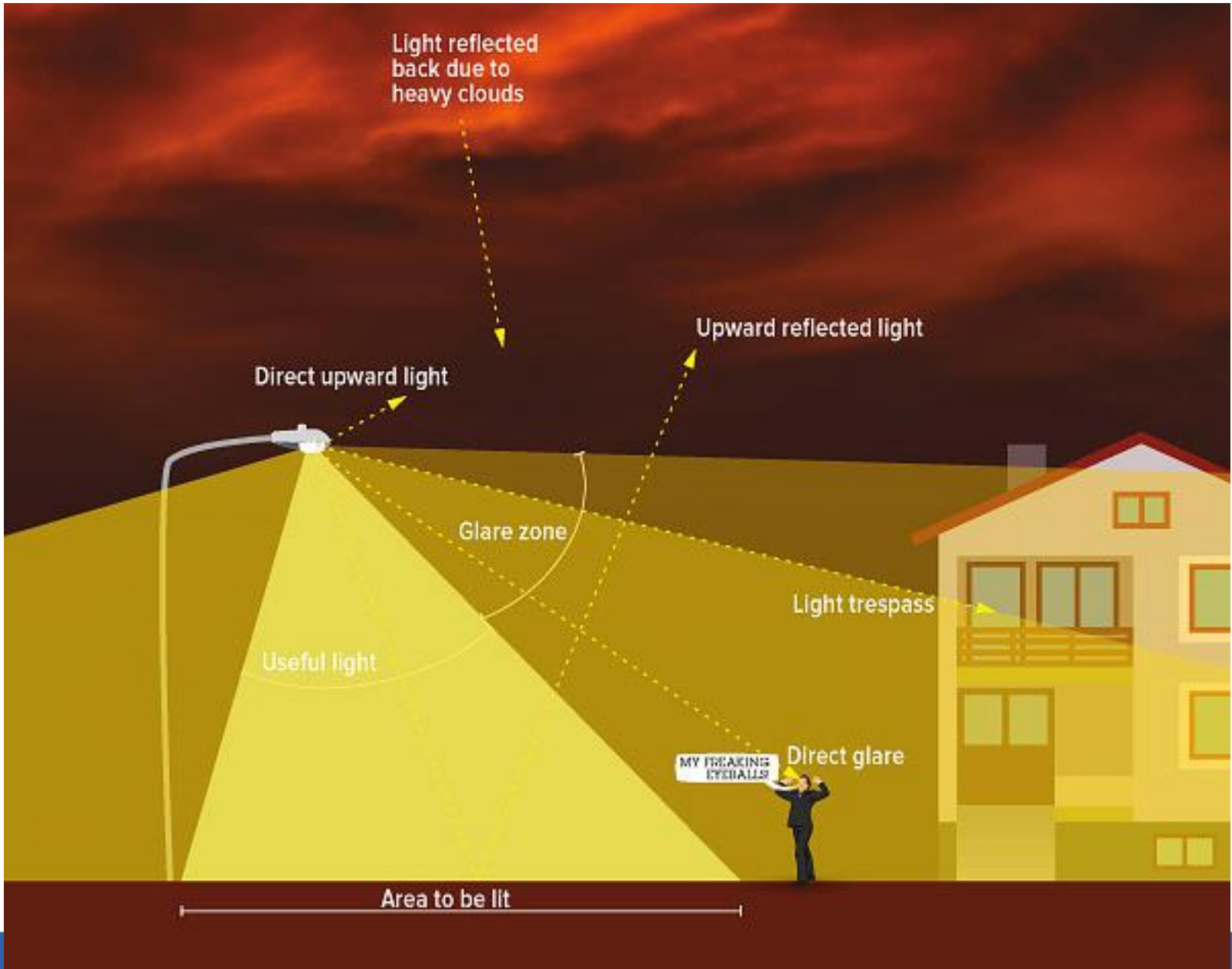


3000 Kelvin



4000 Kelvin





Night-time satellite data

Defense Meteorological Satellite Program – Operational Line Scanner (DMSP-OLS) and Visible/Infrared Imager Radiometer Suite (VIIRS) are most commonly used night-time lights data. In summer 2018 a new Chinese night-time satellite, LuoJia 1-01, was launched, providing imagery that is much more accurate than those of the previous satellites.

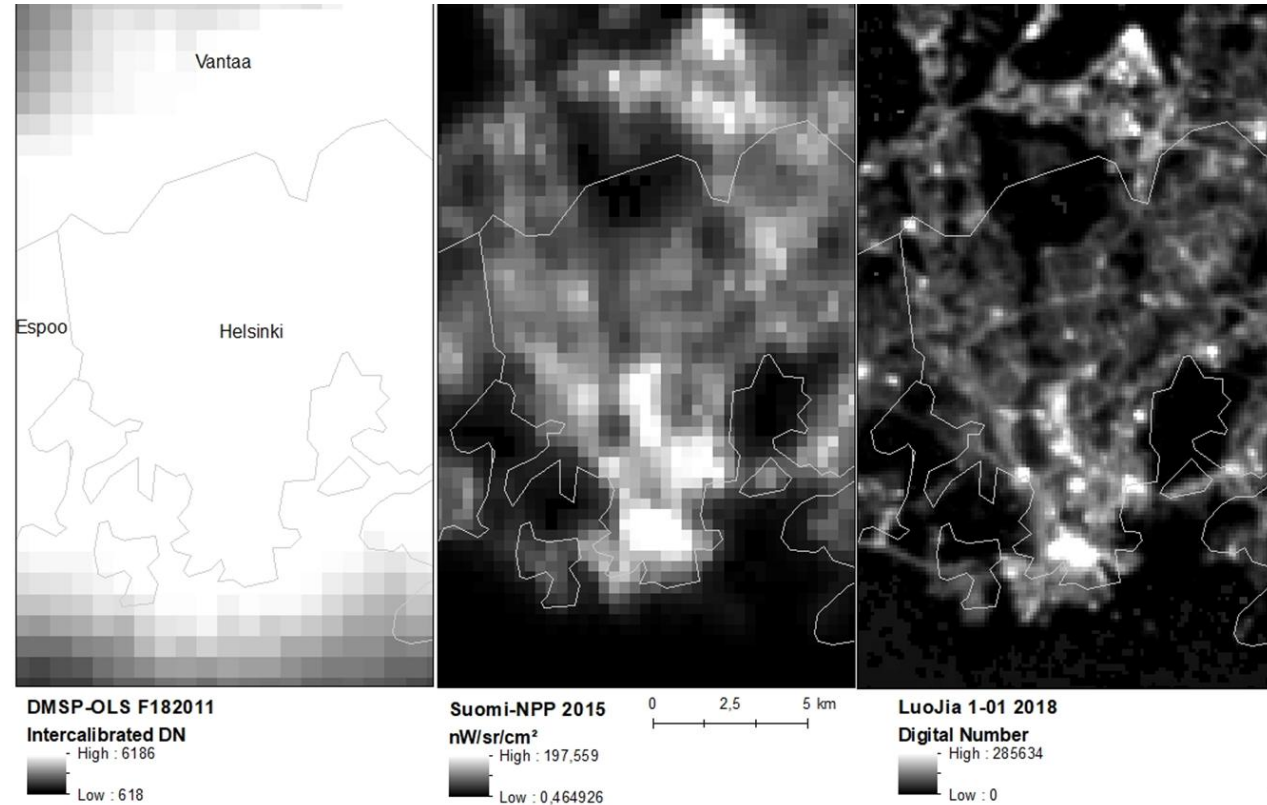
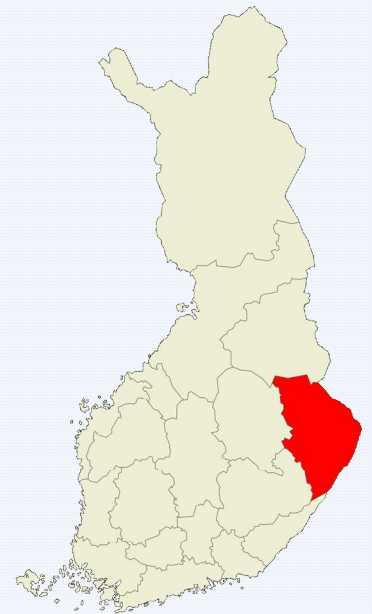


Table 1. Comparison of parameters for different NTL data.

Parameters	DMSP/OLS	NPP/VIIRS	LJ1-01
Available Period	1992–2013	November 2011–present	June 2018–present
Country	The U.S.	The U.S.	China
Spatial Resolution	2.7 km	740 m	130 m
Swath	3000 km	3000 km	250 km
Spectrum Range	0.5–0.9 μm	0.5–0.9 μm	0.46–0.98 μm
Radiometric Resolution	6 bits	14 bits	14 bits
Saturation	Saturated	Not saturated	Not saturated

Health record data

- Health records from patients with diagnose for type 2 diabetes (E11), sleep disorder (F51), Crohn disease or Colitis ulcerosa (K50, K51) or depression (F32, F33) will be collected from Norh Karelia health district (Siun sote) area.
- In addition to diagnoses, other health information related to melatonin production like body mass index and metabolic factors will also be collected
- Health records will be connected to patients residence history by Population Register Centre
- To test how the outdoor light levels affect the relative risk to these diseases, the outdoor light levels of their residency prior to getting sick will be collected from satellite images 10 years prior to their condition
- This connection has been found for breast and prostate cancers, but other types of diseases that are affected by melatonin production haven't been tested widely yet



Other factors

- **Patient characteristics**
 - Age, gender, laboratory results, home address (Electronic patient database)
- **Socio-economic variables** (250m*250m grid level)
 - Median income, (thousands / €), Educated (%), Unemployed (%)... (Statistics Finland)
- **Greenness of the living environment**
 - People living in greener areas tend to have less chance of developing T2D or depression. This should be taken into account, maybe with NDVI (Normalized Difference Vegetation Index) images

Bright and blue-rich light-at-night disrupts circadian rhythm, leading to increased health risks and ecological impacts.

By optimizing our lighting design and the spectrum of the light produced, these health risks could be avoided or at least minimized.

Energy efficient lighting system without increased health or ecological harms is also possible.

Thank you for your attention!

anttihil@uef.fi

Health risks associated with light-at-night (LAN)

- Increased risk of prostate and breast cancer
 - Hormonal types of cancer where melatonin production and/or clock gene is disrupted by light exposure. Melatonin also regulates other hormones that influence cancer.
- Obesity
 - Light exposure can affect metabolism, causing gain in fat and body mass in animal experiments even when calorie intake and daily activity levels are constant. Short sleepers lost less fat than longer sleepers despite similar overall weight loss in human experiments.
- Diabetes
 - Blue-rich light disrupts circadian rhythm, suppresses melatonin, increases appetite and increases insulin resistance and glucose intolerance.
- Depression
 - Even small amount of LAN is linked to increased risk of depression, especially blue-rich light

Ecological effects

Most organisms have adapted their behavior on natural night-day cycles. Other species that have been highlighted to have negative harm from artificial lighting are birds, bats, fish, insects, mammals and plants.

