Hyperspectral study of the impact of private lighting on skyglow at the Asiago Observatory, Italy

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Objectives

1. Assess the state of the night sky at the Asiago Observatory.
2. Identify the main sources of light pollution.
3. Estimate the contribution of private lights.

Context

The Asiago Observatory is a site that is located in the north of Italy, nearby a very densely populated region.

Figure 1: Modeling domain extent

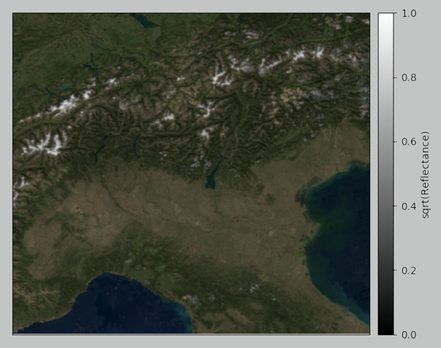

Figure 2: Reflectance (MODIS)

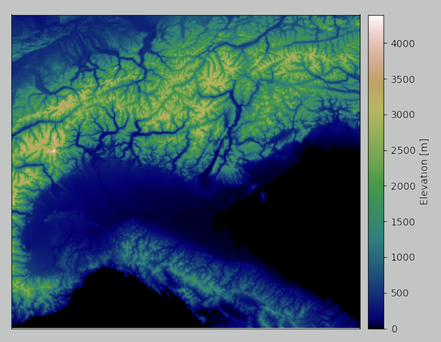

Figure 3: Elevation (SRTM)

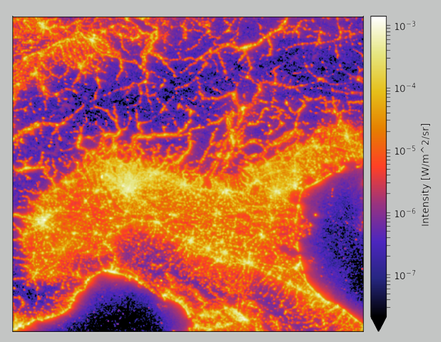

Figure 4: VIIRS-DNB night lights

Model used

Illumina model [1].

- Ray tracing algorithm
- Hyperspectral support
- Shadowing effect of topography
- Explicit 1st and 2nd order scattering
- Lambertian ground reflectance
- Subgrid obstacles
- Atmospheric extinction
- Light angular distribution
- Any observer position and viewing angle
- Aerosol type and concentration
- Relative humidity
- Cloud scheme

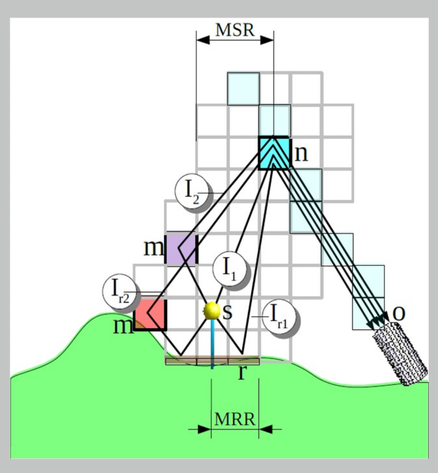

Figure 5: Illumina model.

Light inventory

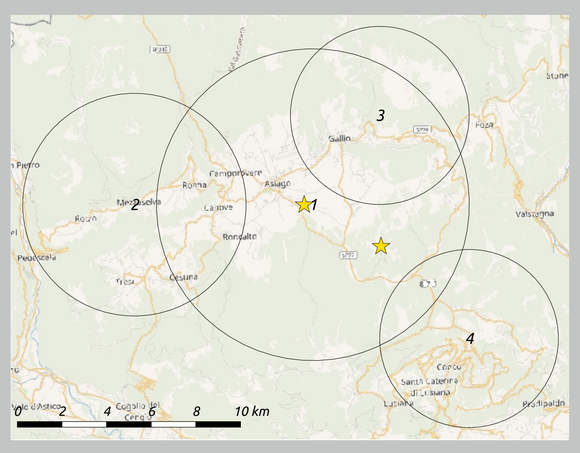

Figure 6: Nearby municipalities description. Observatories marked by stars.

- Municipal inventory of public fixtures.
- In-situ survey of public and private lights ratio.
- Survey scaled to match the in-situ high pressure sodium count of the municipal inventory to obtain the technology usage ratio.

Light inventory (cont.)

The technology usage ratio for the region outside of the nearby surveyed municipalities is estimated for each pixel on the image taken by astronauts on the International Space Station (ISS) by using the method proposed in [2]. The luminance of each pixel is normalised by the intensity in the green band. The usage ratio for a given technology t is then obtained as

$$R_t = \frac{d_t^{-1}}{\sum_n d_n^{-1}} \quad (1)$$

where d_t is the "distance" in color space between the pure technology t and the given pixel. The summation is made over all considered technologies. For this image, we obtain 67% sodium lights and 33% of white (LED or metal hallide) lights.

Figure 7: Image of the Veneto region from the ISS.

Results

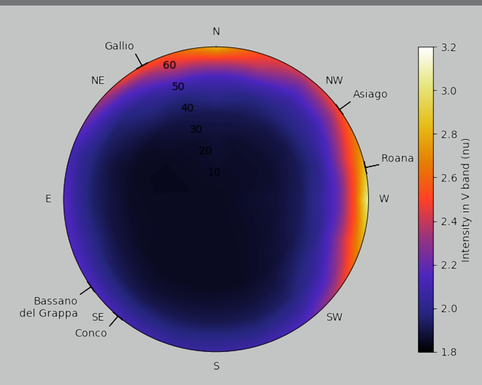

Figure 8: Asiago artificial sky radiance in the V band in units of the natural background.

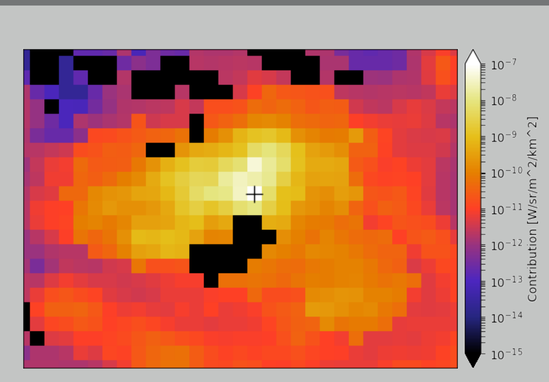

Figure 9: Origin of the zenithal artificial radiance in the V band for Asiago. (Observatory marked by +)

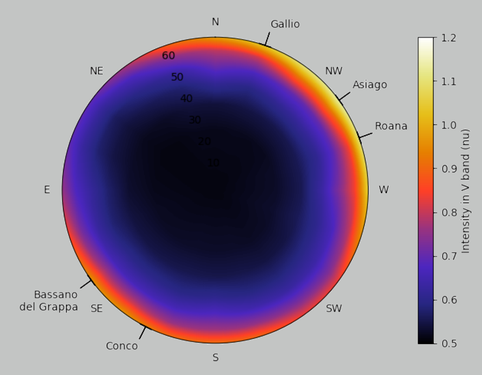

Figure 10: Ekar artificial sky radiance in the V band in units of the natural background.

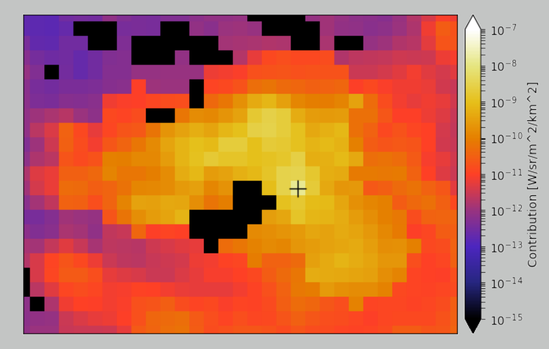

Figure 11: Origin of the zenithal artificial radiance in the V band for Ekar. (Observatory marked by +)

Johnson-Cousin band	Zenith radiance		Priv. contrib.		90% dist.	
	Asiago	Ekar	Asiago	Ekar	Asiago	Ekar
R	0.94	0.27	0.11	0.09	4.2	13.9
V	1.85	0.51	0.15	0.12	4.5	12.1
B	1.14	0.32	0.17	0.14	5.1	9.5

Table 1: Parameters of the artificial sky radiance at both locations for the zenith. The artificial radiance are in units of natural sky background [3], "Priv. contrib." refers to the contribution of private lighting and "90% dist." refers to the distance in km around the observer that produce 90% of the artificial radiance.

Conclusions

- The artificial sky radiance is darker at Ekar compared to Asiago by a factor ≈4. This is because it's located further away from the municipalities in the area.
- The Asiago artificial sky is roughly 2 times brighter than the natural one, while the one at Ekar is about half as bright.
- About 10-15% of the light is coming from private fluorescent sources. It's a major contributor.
- The major sources for the Asiago observatory are withing 5km, and within 15km for Ekar. The local sources are hence the most important to consider for their impact on the sky.

Acknowledgements

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References

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