PhD Project

Light Pollution: A groundbased measurement campaign and research in synergy with satellite data

Proposer Dr. Claus Gebhardt, Earth and Planetary Science Unit, NSSTC

Dr.Claus Gebhardt,+971 3 713 4487, claus.gebhardt@uaeu.ac.ae

Light pollution is a worldwide problem that is gaining increasing attention. It is known to have negative impact on the orientation of wildlife (turtles, birds, insects, …), ecosystems, human health, the night sky heritage, astronomy, etc. Moreover, it is indirectly linked to other environmental issues such as energy consumption, CO2 emission, air quality, etc.. In line with that, the International Dark-Sky Association IDA (https://www.darksky.org/) was founded in 1988. For raising the awareness of nature conservation, the Earth Hour takes place each year, including the UAE. As widely known, this means that organizations and individuals are encouraged to deactivate any unessential light for 1 hour. The last Earth Hour was on Mar. 28th, 2020, 8:30 to 9:30 pm local time. It was organized by WWF and partnered by Emirates Nature WWF (https://www.earthhour.ae/).

Last but not least, Space Science Outreach is a stake holder. The night sky fascination starts with naked-eye-stargazing and the use of casual equipment (e.g. portable telescopes). It is a known fact that this is of key importance for space awareness raising, not only among the young generation. Such activity is also compromised by light pollution. The so-called Bortle Scale allows any naked-eye-observer to rate the quality of the night sky. While Bortle Scale 1 is an ideally dark night sky, higher levels extend up to 9 and represent different degrees of light pollution [e.g. https://en.wikipedia.org/wiki/Bortle_scale; Bortle(2001)]. Already intermediate Bortle values may be a basis for impressive night sky observations, e.g. the Milky Way at Bortle Scale 4.

Light is pollution is mapped globally and studied scientifically through earth-observation satellites. As to that, the New World Atlas of Artificial Night Sky Brightness [Falchi et al.(2016)] is based on satellite observations by the Suomi National Polar-orbiting Partnership (NPP) satellite. It is made publicly available via different light pollution apps (e.g. https://www.lightpollutionmap.info). Also, light pollution databases derived from night photographs by astronauts on board the International Space Station are currently under development (https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/International_Space_Station/Astronauts_and_citizens_team_up_against_light_pollution). Related to Suomi NPP, the following technical challenges are known [Kyba et al.(2015)]

- The spatial resolution is ca. 750 m (possibly too coarse for special points of interest)
- The typical local time of satellite overpass is ~1:30 am (i.e. limited temporal resolution)
- Repeat cycle is 16 days
- “cloud-free composite” images of a location are based on many satellite overpasses on cloud-free moonless nights (strong limitation for generating time series).

The idea of this PhD project is to explore the night sky properties at selected points of interest by self-conducted groundbased measurements, using technically sophisticated equipment. The latter will be given by spectral imaging instrument(s). For instance, wide field CCD cameras used for night sky

surveys in US National Parks have a cost of ca. $5000-15,000 US and take ca. 30 minutes for scanning the entire sky [Duriscoe et al.(2007)]. This is followed by image processing using GIS software. The result are all-sky datasets with image-like information including all directions. The anthropogenic and natural components of sky brightness are disentangled with the help of model assumptions [Duriscoe(2013)]. The latter account for various natural light sources including galaxies/stars, zodiacal light, and earth-atmospheric airglow. The latter are potential cross-links to Earth Atmospheric Science, Space Science, and Astronomy.

The spectral resolution of data holds important clues linked to the spectral composition of light. The latter may vary significantly depending on the light sources used (e.g LEDs vs. vapor lamps). Taken together, diverse science questions can be addressed on this basis. To give an example, the planned all-direction-data are similar to what nocturnal animals perceive. Thus, the link between nocturnal animals and the spectral composition of light can be studied. Also, the planned work may be relevant to innovative engineering solutions such as intelligent lights. In any case, available satellite data (SUOMI NPP, ISS, …) will be used as complementary information.

This project will be based at NSSTC, UAEU, Al Ain. Basically, we are open for any collaboration with environmental agencies and similar, provided that there is a significant overlap of interest.

References

Bortle, J. E. (2001) 'Introducing the Bortle Dark Sky Scale', *Sky & Telescope,* 101(2), pp. 126.

Duriscoe, D. M., Luginbuhl, C. B., and Moore, C. A.: Measuring Night-Sky Brightness with a Wide-Field CCD Camera. Publications of the Astronomical Society of the Pacific, 119: 192–213, 2007.

Duriscoe, D M.: Measuring Anthropogenic Sky Glow Using a Natural Sky Brightness Model. Publications of the Astronomical Society of the Pacific, 125, 2013.

FALCHI, F., CINZANO, P., DURISCOE, D., KYBA, C., ELVIDGE, C. D., BAUGH, K., PORTNOV, B. A., RYBNIKOVA, N. A., FURGONI, R.: The new world atlas of artificial night sky brightness, *SCIENCE ADVANCES,* E1600377, 2016.

Kyba, C.C.M., Garz, S., Kuechly, H., De Miguel, A.S., Zamorano, J., Fischer, J., and Hölker, F.: High-Resolution Imagery of Earth at Night: New Sources, Opportunities and Challenges. *Remote Sens.*, *7*, 1-23, 2015.