eALAN 2020

WELCOME TO eALAN 2020

"The surface of the Earth is the shore of the cosmic ocean. On this shore we've learned most of what we know. Recently, we've waded a little way out, maybe ankle-deep, and the water seems inviting. Some part of our being knows this is where we came from. We long to return, and we can because the cosmos is also within us. We're made of star stuff. We are a way for the cosmos to know itself."

-Carl Sagan

ALAN

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Cover photo and booklet design: Bettymaya Foott

#eALAN2020

Dear eALAN participants,

The 6th International Conference on Artificial Light didn't work out quite the way we expected…

We were looking forward to welcoming you to Lleida, and we were particularly excited about the program, as there were more abstracts submitted than at any ALAN conference to date. While it is unfortunate that COVID-19 prevented us from meeting in person, we are still excited about this first experiment with an electronic ALAN. While the oral program will be abridged compared to the original plan, we expect the talks to be superb, and it appears likely that we will actually have more attendees than we would have had in person.

After the conference, we will be sending all registered participants a link to participate in a survey about the electronic version of ALAN. We hope you will take part! If you are not already signed up for the conference mailing list, please take a moment to sign up now, so that you will receive our call for papers for ALAN 2021 and ALAN 2023: http://tinyurl.com/alan-signup.

The hashtag for this year's conference is #eALAN2020. Oral presenters should keep in mind that if you do not want audience members to live tweet your talk, you should make this clear at the start of your presentation.

On behalf of the steering committee, I would like to deeply thank the organizers of LPTMM for agreeing to postpone LPTMM to 2022, so that we avoid having both conferences take place in the same year. We are also very thankful to Salvador Ribas, Fernando Jáuregui, and the rest of the organizational team from Lleida for agreeing to host ALAN in person again in 2021, and for the team from the following ALAN conference for agreeing to postpone from 2022 to 2023. We also thank all ALAN authors and attendees for your understanding as we transition to eALAN for 2020. I am personally extraordinarily grateful to the other members of the international steering committee for their considerable efforts to plan eALAN 2020, following the work of the initial planning of ALAN 2020 in Lleida.

Since the last ALAN conference, we have lost three colleagues who attended several ALAN conferences in the past, and who were friends to many of us in the artificial light at night research field: Abraham Haim, Richard Stevens, and Thomas Posch. We are grateful to Anat Barnea, George Brainard, and Stefan Wallner for agreeing to prepare presentations dedicated to their memory.

Finally, thank you once again for attending eALAN! Without your participation, the conference would not exist.

Sincerely,

Christopher Kyba
Chair of ALAN steering committee

ALAN

FROM THE ORGANIZERS

Dear eALAN participants,

Around two years ago, during ALAN 2018 in Utah, the steering committee announced the venue for ALAN 2020. I was extremely happy to lead the local organizing committee that planned to host this event in Lleida (Catalonia, Spain).

Parc Astronòmic Montsec has been always linked to the study and protection of the night sky, and we have organized many events in our natural area of Montsec. This time, we planned to host a big event, the most important conference on the topic. We therefore decided to host it in the city of Lleida, the main city of our region in the inner part of Catalonia, one of the oldest Mediterranean countries states.

We planned for ALAN 2020 to be a key event of our European Union Project called Pyrenees: la nuit. This international project has the main aim of analyzing and protecting the natural nighttime environment in the whole Pyrenees. We have worked in cooperation with all of the others partners of the project to develop actions linked to research, outreach, and strategies related to artificial light at night and its effects.

Our lives have changed very much since that moment in Snowbird (Utah, USA) that we joined the steering committee to create a new wonderful event in 2020. The appearance of the famous COVID-19 has changed and will continue changing how we proceed in all our actions day after day. After evaluating the situation in March 2020, both local and international organizers took the right decision of postponing the on-site event until next year. I believe this is surely the best decision, given what happened around the world.

I want to thank the ALAN steering committee for finding a way to keep Lleida as the next venue of a physical ALAN conference, in 2021. And also I want to thank all the members of the local committee that were always ready to prepare the event. We will be ready to host all of you in Lleida next year!

Finally, instead of being only postponed, the 6th International Conference on Artificial Light at Night 2020 came together as a new real event (eALAN 2020). This will give all of us the chance to meet and discuss using new technologies, and it was only possible thanks to the hard work of our local and international committees to convert the event to an e-conference.

Let's enjoy this online event, and open new discussions that can lead to new contributions for next Artificial Light at Night 2021 in Lleida. Thanks again for attending this eALAN, and see you in one year in ALAN 2021 in the city Lleida. We are already working to ensure a wonderful event next year.

Sincerely,

Salvador J. Ribas
Chair of Local Organizing Committee ALAN 2020-2021

ALAN 2018

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In memoriam: Richard Stevens

Our colleague Richard "Bugs" Stevens, a professor at the UConn School of Medicine and longtime member of the ALAN steering committee, passed away in August, 2019. Richard was a key figure in the field of artificial light at night. In 1987, he published "Electric power use and breast cancer: a hypothesis", which launched the study of the relationship between light at night, melatonin, and breast cancer. In addition to his research, he worked to raise awareness about the negative impacts of ALAN among his colleagues and the public. His advocacy contributed to the decision of the American Medical Association to issue its policy statement on street lights, and he summarized that statement for the public in a piece he published in The Conversation.

Richard was an invited plenary speaker at the inaugural ALAN conference in Berlin in 2013. Following that meeting, we decided to form an international steering committee in the hope of establishing ALAN as a regular conference series. Richard had greatly enjoyed the conference, telling us by email that "the conference was, as I mentioned to you in Berlin, fantastic, and one of the best I've participated in on an important topic". We will forever be grateful that he decided to dedicate his time by serving on the ALAN international steering committee for every ALAN conferences that followed (2014, 2015, 2016, 2018, and 2020).

The ALAN steering committee will greatly miss Richard's contribution, and especially the spontaneous lighthearted jokes that he often peppered our meetings with. Richard was extraordinarily evenhanded in his assessment of potential conference speakers, basing his decisions on the quality of the science and communication abilities of the nominated speakers, rather than his personal relationships with them. After first seeing the speaker long-list for one conference he once commented "I do have particular favorites (not necessarily friends), and several of my favorites I have never met personally." If you have enjoyed an ALAN conference in the past, then you should know that Richard played an important role in shaping your experience.

Our deepest condolences go out to Richard's family, his friends, and his colleagues at UConn and throughout the world.

We dedicate the ALAN 2020 conference to his memory.

Photo: Richard Stevens deep in discussion at the poster session of ALAN 2013 in Berlin.

ONLINE

ALAN RESOURCES

COMMUNITY

ALAN Research database

http://alandb.darksky.org/

LPResearch mailing list

Sign up by sending a mail to:

lpresearch-subscribe@yahoogroups.com

International Dark-Sky Association

darksky.org

ALAN Conference

artificiallightatnight.org

LPTMM Conference

http://lptmm.org/

Consortium for Dark Sky Studies

darkskystudies.org

DATA

VIIRS DNB data online visualization

lightpollutionmap.info/

VIIRS DNB data download

ngdc.noaa.gov/eog/viirs/download_dnb_composites.html

Astronaut Photographs

www.citiesatnight.org

World Atlas of sky brightness floating point data

http://doi.org/10.5880/GFZ.1.4.2016.001

VIIRS DNB overpass time predictor

www.ngdc.noaa.gov/eog/viirs/predict/

VIIRS DNB nightly mosaics viewer

maps.ngdc.noaa.gov/viewers/VIIRS_DNB_nightly/

Viewing/accessing Globe at Night data

www.myskyatnight.com/

Sunrise/sunset calculator

www.timeanddate.com/sun/

Moonrise/moonset calculator

www.timeanddate.com/moon/

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International Journal of Sustainable Lighting

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- **Help us build a community of scholars:**
The IJSL is an international platform for sustainable lighting research from a multidisciplinary standpoint.
- **Critical curiosity appreciated**: What sets us apart is a focus on emerging consequences of artificial light at night rather than solely the discussion of light efficiency.
- **All are welcome**: The IJSL supports theoretical, applied and experimental research for a range of disciplines such as energy, ecology, biology, green buildings and astronomy.

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How to submit research to the IJSL:

1. Navigate to www.lightingjournal.org
2. Register an account
3. Select "Make a Submission"
4. Review the guidelines

For more information, visit lightingjournal.org

Image credited to Till Teenck, retrieved from https://en.wikipedia.org/wiki/File:Light-Bulb_icon_by_Till_Teenck_blue.svg

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Extended park: the integration of light with technology transcends the physical limits of the park, promoting social inclusion and knowledge.

Theme: Technology and design

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Introduction

Montevideo is the capital city of Oriental Republic of Uruguay, located on the Rio de la Plata bank. An important vehicular traffic road and a pedestrian promenade borders the coast along 24 km. A set of Urban Public Parks are all over the city, where the "Rodó", object of the present work, is located next to the coastal edge and close to the city center. With an area of forty-three hectares, it constitutes a traditional walk for both citizens and visitors.

The project mode of the Montevidean parks of the late nineteenth and early twentieth centuries was configured by the picturesque English design and executed by landscape designers and technicians trained in France. Rodó Park is an urban postcard that captures dreams and ideals about national identity of the last century´s first decades. Besides, it was an urban lung as a hygienist demand, a learning tool for the population and an element of beautification of the city, conceived as a requirement for the new capitalist productive system of the modern state. Moreover, it exposes a select repertoire of poets, writers, national thinkers, mythological characters and the testimony of immigrant groups that motivate the sculptures. The park recreates the "literate city" ideal.

Fig. 1 : Aerial view of Parque Rodó in 2008.

The aim of this intervention is the promotion of areas for the inclusion and coexistence of people, consolidating multiple and diverse meeting places to enjoy day and night, as well as to provide knowledge.

Methodology

A previous study was conducted to design the light conditioning. It was carried out in two phases, an urban and a social analysis.

For the urban study it was considered: a.- Location Analysis, includes formal aspects (structure and style), dedication, and compositional architecture and relations with the environment; b.- Significance, history, present and future, and their connections; c.- Actual Situation, where the vestiges of successive light conditioning have altered the park landscape visualization, causing a state of "visual disorder", coexisting luminaries and technologies from different eras; d.- Stakeholders, people, groups and institutions, that could affect the development of this project; e.- Institutionalism, align with the strategic guidelines of the organization and the current Territorial Ordering Plan; f.- Prospective look, it anticipates the development of other scenarios and technological changes that could affect the proposed solution.

The social study was focused on the knowledge of the perception and uses of the Park that different segments of the public have, in order to generate polices linked to it. To execute the study suggested, a qualitative analysis was carried out oriented to know the perceptions and meanings, throughout an anthropological approach to study

the impacted ethnographies and the type of associated involvement. And finally, a quantitative analysis of needs. From the results obtained, it appears that lighting is problematized through security, being one of the worst evaluated aspect (21% of disapproval). Women avoid crossing the Park at night, going to dark and dangerous places (because of robs and sexual harassment). What's more, lighting does not contribute to an identity, due to the heterogeneity of light styles. In addition, the lack of knowledge of the neighbors about cultural activities in the neighborhood as well as the existing monuments, is striking.
This study provided conceptual support for the development of the light design. Two concepts were worked on, which allowed the link between the past and the present, and also addressed the purpose of this intervention: 1- "Extended Park": through lighting, technology and the use of mobile phones, the park transcends physical limits. Furthermore, a set of actions is provided to guide the user to rediscover the immaterial value of it pieces and the richness of its landscape. The mobile application has different sections; contextual and historical images of the park, georeferencing and information of points of interests, and the incorporation of interactive modules of referential presence to interact with the monuments, depending on the time of the day. 2- "The light integrates": conditions of equity were established that guarantee universal access to the park services. Lighting levels were defined considering the layout of the existing walk path, zoning the space according to the use and determining unique points of interest.
In addition, the design includes the installation of video cameras to favor the development of new interventions, the procurement of information and the sense of public protection. The proposal revalues the main activities; walking, contemplations and leisure. It adapts to the temporality of different activities, keeping the calm and formal character. Globally, it maintains its likeness and uniformity on a human scale, preserves its warm atmosphere, and the architectural, sculptural and landscape points of interest stan0ds out. Quantitative results of the interventions will be presented one year after the installation is fully operational.

Conclusions

The light design is an essential tool to promote culture, where patrimony and knowledge are encouraged. From a social point of view, the extension of technology from home to the park, the formation of friendly and inclusive social relationships and universal access are promoted.
The concepts of "Extended Park" and "The Light Integrates", together with a technological, prospective and flexible approach, allowed to generate a dynamic installation that integrates space and people.

References

- Fig. 1: Aerial view of Parque Rodó in 2008

  Ref.: 9652FMCMA.CMDF.IMM.UY – ©Carlos Contrera / CMDF.
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LuMinAves: cooperative research and mitigation of light pollution impacts in seabirds

Society, Biology and Ecology

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Introduction

Light pollution can have conspicuous effects on biodiversity. In urbanized coastlines, juvenile seabirds initiating their first migrations are disoriented and attracted by night light, falling into the streets. Fallout events have mobilize local communities to conduct rescue campaigns, currently active in 16 localities worldwide, where volunteers and specialists search for, collect and release, thousands of fallen juveniles (Rodríguez et al., 2017). These actions reduce juvenile mortality by light pollution, raise community awareness and generate long-term citizen-science datasets. The Macaronesian archipelagos, where fallouts are common, designed the collaborative project LuMinAves to reduce light pollution and enhance mitigation of its impacts unto seabird populations. The project's actions and results are organized into three approaches: knowledge, dissemination, and, mitigation and urban planning.

LuMinAves is a project funded by European Territorial Cooperation programme INTERREG V-A Madeira-Azores-Canary (MAC/4.6d/157) 2014-2020, granted in 2016 ending in 2020. It is operated by 6 partners financed by FEDER: SEO, IFCN, DRAM, FRCT, SPEA Açores and SPEA Madeira; in collaboration with non-operational partners: Viceconsejería Medioambiente del Gobierno de Canarias, Cabildo Insular de Tenerife, Cabildo Insular de Fuerteventura, Cabildo Insular de Gran Canaria, Instituto de Astrofísica de Canarias (IAC), Câmara Municipal do Corvo, Empresa da Electricidade da Madeira (EEM) and Electricidade dos Açores (EDA).

Knowledge. To assess the magnitude of light pollution impacts, as well as the effectiveness of conservation actions, seabird population parameters will be used as indicators. Seabirds are challenging to study due to their burrow-nesting habits, inaccessible colony selection and nocturnal behaviour preferences, thus obtaining data from different methods and sources can provide for more accurate knowledge (Orben et al., 2019). The project conducted systematic monitoring to estimate parameters of affected species (colony location, abundance, breeding success and survival rates). Ringing sessions were conducted, targeting nearly-fledged chicks at colony. If found during the rescue campaign, ringed chicks will help identify colonies most vulnerable to light pollution. However, less than 1% of individuals ringed at colony were rescued during the campaign. We have also tagged GPS-data loggers to fledglings to unravel the flight characteristics in relation to light pollution distribution (Rodríguez, Rodríguez, & Negro, 2015). Finally, fragmented campaign data is being coalesced into a common Macaronesia database detailing location of rescue, health condition, ringing and biometric data of rescued individuals, as well as information on volunteers and rescue effort. This database is now a permanent ongoing effort, and will extend the project's results and contributions beyond its lifecycle.

Dissemination. Through the project meetings, partners shared the methods and practices used in their rescue campaigns, streamlining procedures and data collection. To provide essential geographical data of light pollution impacts, campaigns now record GPS location of fallen birds, and data from urban lighting is being coalesced for further analysis. Outreach tools have been produced, including a website (http://www.luminaves.com/index.php/es/), mascot, bilingual informative fliers and best practices informative videos. LuMinAves has been represented in six festivals, and organized local and regional events. Project partners have given over 100 public talks on LuMinAves, light pollution, its impacts on seabirds and best practices for urbanization, with more than 2600 participants.

Mitigation and Urban Planning. Innovative "blackout" pilot studies are being conducted to test new lighting schedules and lamp types during critical periods for seabirds. Workshops are being held at regional and local levels, to define actionable solutions of sustainable lighting schemes, by creating a space for collaborative and interdisciplinary discussion with the major actors and stakeholders involved. From the common database and workshops it was possible to create geographical maps that allowed for the identification of lit areas with high numbers of seabird fallout. The Azorean Electric Company is currently upgrading the archipelago's lighting scheme, from sodium to LED lamps, and is using these results to identify areas where to, eliminate, change or reduce lighting, avoid the placement of bright white LEDs, and where to implement low-energy or blackout timers.

Future. LuMinAves provides a platform for further development of research and policies. A PhD proposal, accepted in 2019 and within the project's frame, will continue research into seabirds and light pollution. A list of cross-disciplinary research topics featuring other taxa will be presented to partner Universities as a series of MSc topics. Project partners are currently working together with regional parliaments to submit regulatory legislation regarding lighting protocols. A new INTERREG project, led by IAC, will be building on the progress achieved by LuMinAves, and is expected to hold a conference addressing light pollution by the end of 2020.

The final outcome of the project will be a comprehensive action-plan combining: current knowledge on light pollution and lighting practices; results from the several experiments and monitoring actions; improved protocols on rescue campaigns, data collection and lighting practices; geographic information on light pollution in Macaronesia; and specific actions for stakeholders and partners. Ultimately providing common tools for the implementation of new concepts of sustainable lighting, improvement of public lighting and associated policies, returning Macaronesia to its natural nightscapes.

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Night sky brightness distribution, colour changes yearly, hourly, and by minute at MHAONB, due to UK weather effects over distant town Lighting conversions.

Theme: Measurement and modelling

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** Chris Baddiley*

Introduction.

The sky in the Malvern Hills Area of Outstanding Natural Beauty (MHAONB) has been monitored continually since 2012 at Mathon observatory. A dark sky survey of the area was carried out in 2012, commissioned by Malvern Hills Conservators, and in 2015 they asked the author to model the expected effects of blue-rich LED conversion across Herefordshire and Hereford city in the AONB. The modelling is based on luminaire polar distribution illumination ray tracing, with ground scattering and atmospheric altitude and aerosol density dependent phase scattering, integrated along any view path.

The sky brightness has been measured continually since 2013, in the last few years at two minute intervals in all weathers. On the darkest of nights, a fisheye lens camera was used at the same interval, viewing to the horizon in all directions.

There has been a steady trend of increasing brightness and changes from orange pink to blue white close to the horizon. This is very localised from individual towns and city luminaire conversions, mostly beyond the horizon. It is extremely dependent on the weather, which has become increasingly variable and rapidly changing in the UK. The brightness and colour changes can occur over minutes from orange to blue-white and back again, affecting the local sky greatly. This is caused by variable height cloud reflection with scattering over the distant towns or intervening attenuating mist, rapidly coming and going, affecting the local clear sky. The number of clear sky nights in new moon periods was just a few in 2019, but greatly increased into spring of 2020, while in Coronavirus lockdown, so adding to the studies.

This presentation shows some examples of these changes hour by hour. Several cameras were used over the 8 year data gathering period, but their spectral responses were shown to be similar. The sky quality meter (SQM) photometry data near Zenith does not show any great change over the years

Who speaks for the night? The regulation of light pollution in the 'Rights of Nature' legal framework

Theme: Society

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Introduction

Efforts to control artificial light at night (ALAN) through public policies began in the late 1950s, yet light pollution continues to grow at a global average rate roughly twice that of population growth (Kyba et al. 2017). The current global ALAN regulatory regime is clearly inadequate to solve the problem, and achieving meaningful light pollution reductions requires a new approach. This presentation advances the idea of nighttime darkness as a natural characteristic of sufficient inherent value to merit legal consideration in the "Rights of Nature" context.

Failures of current policy and possible alternatives

There are two main shortcomings of existing legal mechanisms used to restrict the use of ALAN in order to reduce the impacts of light pollution. One is the lack of public awareness and/or support for such policies that leads to failures of implementation and enforcement. The other is that the dominant (Western) legal approach prioritizes the human exploitation of natural resources and limits justice for alleged harms to nature resulting from human activities to proving torts by demonstrating that a natural or juridical person sustained an injury due to those activities. Suits in which plaintiffs allege that nature itself has suffered are usually dismissed for lack of standing.

Ways forward might take cues from other environmental concerns, such as the global climate change crisis; taxes and cap-and-trade schemes are suggested as a means of affecting carbon emissions reductions. Taxing carbon itself, rather than applications of carbon-based fuels, is thought to have a more direct impact on behaviors with respect to energy use; therefore, excise taxes on lighting products based on the number of lumens of light they emit may be more effective at limiting ALAN than taxing the electricity consumption of increasingly energy-efficient outdoor lighting.

Another approach to changing the regulatory regime involves appealing to the idea of natural darkness as a form of public good that is not the sole province of any particular entity to pollute without consequence. To the extent that ALAN emission becomes skyglow, the scientific and human heritage value of the night sky makes it a commons; furthermore, it is argued that light pollution is a colonizing threat to the cultural integrity of indigenous peoples (Hamacher, De Napoli, and Mott 2019).

Understanding the legal setting

In order to consider the full range of legal tools available to address the problem of light pollution, three questions must be answered in the affirmative: (1) Are claims of harm due to light pollution justiciable? (2) Can light pollution create conditions of tort? (3) Does light pollution yield harm to the environment that does *not* result in tort? World case law indicates that courts have found claims relating to light pollution to be justiciable, and the enactment of light pollution legislation in several countries implies that such laws are constitutionally permissible in those jurisdictions. Light pollution has been found to constitute both public and private nuisance. The possibility that ALAN can cause substantial harm to human health and wellbeing, and that ALAN represents a material threat to the continued viability of ground-based astronomical research, may further imply conditions of tort. But there also exists abundant evidence that ALAN threatens a variety of plant and animal species that results in no apparent harm to any person.

Rights of Nature in the light pollution context

The "Rights of Nature" (RoN) movement emerged in reaction to perceived failures of existing policies and legal traditions to deal effectively with ongoing environmental degradation by both public and private entities (Boyd 2017; Houck 2017; Pecharroman 2018). RoN asserts that nature has the right (1) to exist in an unaltered state; (2) to continue to exist in that state; and (3) if degraded, to be restored. Its key legal innovation confers on nature a status akin to juridical personhood and standing to otherwise unharmed natural persons acting as its representatives to bring suit on its behalf.

RoN may apply to natural nighttime darkness and light pollution on the presumption that nighttime darkness has intrinsic natural value. This can be modeled on other forms of environmental pollution with existing statutory prescriptions for regulation and remedy within the RoN framework. Degradation of natural darkness would then be subject to court orders for restoration. However, challenges exist involving the need for balance between the existence of humans in the world and the imperative to protect nature from the consequences of human activities. Furthermore, RoN are not recognized in most world legal systems. On the other hand, the progressive recognition of civil and human rights has overturned existing traditions, and extending rights to the natural night may be just the next step in this historical march.

Until and unless RoN makes greater inroads with legal systems around the world, short-term actions involve pushing for statements of legislative intent in environmental laws acknowledging the intrinsic value of natural darkness and the threat to its integrity represented by light pollution. While these provisions are not themselves enforceable, they offer discretion to those tasked with implementing binding laws as well as judges who interpret laws taking into account not only legal precedent but the intended effects of laws as articulated by their framers. The success of this approach may lead to a future in which nighttime darkness has a place in law that entitles it to better and more comprehensive protections.

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For a Sustainable Approach to Lighting Design in Canada: State of Play and Openness to the Diversity of Dimensions of the Urban Nocturnal Landscape

Theme: Society

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Abstract

What about lighting pollution in North America and more specifically in Canada? For several years, interventions have been put in place to further regulate lighting pollution, however, we notice the difficulty of implementation and the limitation of the tools put in place.

The concept of lighting pollution emerged in the 1970s, especially with amateur astronomers, it raised awareness of the importance of darkness and resulted in the desire to preserve visibility to the starry sky for a population that is increasingly deprived of the admiration of the stars at night. It is also the awareness of the impacts of lighting on fauna, flora and human beings with the disruption of the circadian rhythm.

In North America, several associations such as Dark-Sky have raised public and professional awareness of the challenges of preserving the starry sky. It is also professional associations such as the Illuminating Engineering Society of North America that raise awareness of the impacts and advances in lighting. More particularly in Canada and Quebec, new standards on lighting pollution – 'Bureau de normalisation du Québec' (BNQ, Quebec Standards Office) - and health studies have emerged following the increase of lighting interventions. There are several interventions such as the Mont-Mégantic starry sky reserve, the first world reserve that has opened up new regulatory approaches. It is also the emergence of environmental studies in the case of monumental lighting projects in Montreal that have been carried out in order to ensure the sustainability of the projects. However, there is a denunciation of the inconsistency of the interventions and certain shortcomings in particular in the regulation of the nocturnal urban landscape, considered globally at the scale of cities.

New tools are therefore to be put in place to propose sustainable approaches to lighting, which not only take into account landscape issues, beyond the environmental aspects, and which could also take into account the social and economic aspects. These dimensions, which are often put in the background, seem however fundamental when it comes to understanding how lighting is used, the diversity of stakeholders and the impact that these uses have on the urban scale. On one hand, while we are witnessing the reduction in energy consumption offered by new LED technologies, we are seeing an increase in the use of lighting. On the other hand, it seems that the limited knowledge of the territory at night contributes to the perpetuation of the domination of functional and security approaches which prevent the development of more comprehensive approaches to the territory at night.

Due to its flexibility, new technologies make possible to offer more and more tailor-made nocturnal atmospheres responding to the specific needs of customers and the needs of cities. However, a better knowledge of night-time activities and lifestyles would make possible to adjust so more detailed lighting interventions while implementing sustainable approaches on the social level in particular, with collaborative and participatory approaches integrating not only the various stakeholders but also the populations.

Through a variety of architectural, urban and landscape lighting projects, we therefore propose to better understand the state of the situation in Canada with regard to the sustainable practice of lighting. First of all, there is an important need to clarify what "sustainable lighting" could be, in order to understand the diversity of aspects

that this notion can assume not only at the environmental level, but also by taking into account the social and economic aspects. It is also a review of existing practices and regulations in Canada that will allow to better understand the scope and limits of the actions taken in lighting. Finally, the implementation of pilot projects in the case of Montreal, as part of the development of a research center specializing in nocturnal environments will put into perspective the importance of integrating social and cultural approaches as new ways to design lighting and to better target interventions in order to improve the quality of urban landscapes at night.

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Long Term Evolution of Night Sky Brightness in Veneto Region, Italy

Theme: Measurement & Modeling

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Introduction

The increasing impact of light pollution not only compromises the vision of the stars but also presents negative effects on ecosystems and human health.In recent years monitoring networks have been implemented in many countries around the world, enabling the study of the evolution of the phenomenon over the long term, in addition to spot measurements from the ground and satellite data (Hanel et al., 2017).

In the analysis of the long term evolution of the data collected by these networks, based mostly upon SQM photometers, has been often noted a trend towards a decrease in the sky brightness (Barà et al., 2019): a decreasing trend has been also detected in Veneto region network (Bertolo et al., 2019).

This report analyzes the long-term time trends of Night Sky Brightness in some stations located in areas with different light pollution: measurements made with reference SQMs and other instruments (Digital Single Lens Reflex, Telescope Encoder and Sky Sensor TESS-W, photometric measurements with the telescope) are presented and discussed, in order to confirm the validity of the SQM data and exclude instrumental biases.

Finally, a multifactorial statistical analysis is performed to detect possible correlations of NSB data with astronomical, meteorological and climatic parameters (particulate matter, fog,...) .

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Expanding the ALAN Research Community: Chicago Teens as Light Pollution Researchers and Advocates

Themes: Society/Measurement & Modeling

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Introduction

The Adler Planetarium's Teen Programs group engages hundreds of young people in authentic STEM (Science, Technology, Engineering, and Math) experiences each year. In these programs, teens learn about and understand scientific research and engineering design processes by actively participating in them. The Adler currently offers programs to Chicago-area youth age 11-18 and undergraduate students. Artificial light at night (ALAN) is a critical ecological and astronomical issue (Wainscoat 2009; Longcore & Rich 2004; Navara & Nelson 2007; Gandy 2017). Many young people are unaware of its effects and consequences within their own communities. The Adler Planetarium's Teen Programs group increases public awareness by bringing Chicago's young people into the ALAN research community through innovative, authentic, and engaging programs.

Programs Overview & Outcomes

ALAN is the cornerstone of several youth-serving programs at the Adler. These programs are divided between two areas of concentration: 1) Community Advocacy and Education and 2) Instrumentation and Research.

Work in Community Advocacy and Education began in 2015 growing to a full-scale program in 2016. Youth Organization for Lights Out (YOLO), a bilingual program in English and Spanish, is based at Little Village Lawndale High School in Chicago's predominantly Mexican and Mexican-American Little Village neighborhood. YOLO has successfully been implemented in the classroom as a weekly module and as an after-school club. YOLO program participants use tools to collect and analyze light pollution data, attend field trips to local dark sky sites, facilitate telescope viewing at events at the Adler Planetarium and in their community, and develop prototype solutions and action plans to increase awareness of light pollution's local effects in Chicago. In early 2020, YOLO program participants presented an overview of light pollution's ecological effects and how Chicago's new lighting grid will impact local residents to their alderman. To date, 175 teens have participated in these efforts.

Programs focused on Instrumentation and Research grew out of the planetarium's educational high-altitude ballooning program, Far Horizons. In 2018, Far Horizons astronomers and engineers began developing Mission NITELite (Night Imaging of Terrestrial Environments), a high altitude balloon-based light pollution mapping mission. Undergraduate interns from local universities have been instrumental in developing and carrying out this mission. To complement NITELite, Far Horizons designed GONet (Ground Observing Network), a low-cost all-sky imaging system to measure sky quality at night. In Spring 2019, a cohort of sixteen high school students helped develop, test, and build 50 GONet units. They also created documentation for use by others on how to assemble, calibrate, and operate the devices. Building on the work of their predecessors, in the Fall of 2019 a cohort of teens began deploying GONets to start building a local sky quality dataset.

Reflecting the collaborative nature of science, teens in Instrumentation and Research programs partner closely with peers in Community Advocacy and Education programs. This collaboration encourages young people to learn from and teach their peers while undertaking joint projects. Together these teens continue to deploy instruments throughout the city and collaborate with local scientists whose studies are impacted by light pollution to determine how data collected with GONets can support their research. Program participants are also working with the Cook County Forest Preserve on assessing sky quality at some of their sites with a view to applying for the Urban Night Sky Place designation from the International Dark Sky Association.

By participating in teen programs at the Adler Planetarium teens learn how the oft-overlooked issue of light pollution affects them and their communities while they directly contribute to the ALAN research community and engage local Chicago communities. Chicago's young people are and will continue to be critical members of the Adler Planetarium's ALAN research and outreach team.

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Broad-scale attraction of nocturnally migrating birds to artificial light at night is stronger during autumn than spring across North America

Theme: Biology & Ecology

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Nearly half of the world's bird species undertake migrations twice yearly, traversing large expanses of land and water at continental scales. Most birds migrate at night and stopover repeatedly during the day in terrestrial habitats to rest and replenish energy stores along their journey. Long-distance migrants spend most of the year at extreme latitudes exposed to relatively low levels of artificial light at night (ALAN) during the breeding and non-breeding seasons and generally avoid urban areas of "bright" ALAN (i.e., skyglow from World Atlas (Falchi et al., 2016) is 5 x natural brightness) at this time (La Sorte et al., 2017; Zuckerberg et al., 2016). In contrast, when birds migrate through mid-latitudes where urban development is the most prevalent and widespread ALAN is the brightest (Cabrera-Cruz et al., 2018), they are attracted to cities with bright ALAN at broad scales (La Sorte et al., 2017; McLaren et al., 2018). We hypothesize that this attraction of birds to cities during migration may place them at greater mortality risk from anthropogenic causes (e.g., collision with buildings or predation by cats; Loss et al., 2013, 2014). The novelty of exposure to ALAN during migration may enhance its influence on bird behavior, particularly for juvenile birds during their first autumn migration, which have stronger attraction to city skyglow than experienced birds (Gauthereaux & Belser, 2006). Thus, we predict the following patterns of aggregate bird stopover distributions between and within migration seasons (spring vs. autumn); 1) broad-scale increase of bird stopover density with proximity to ALAN during spring will be weaker compared to autumn because juveniles comprise a smaller proportion of the overall population in spring and are comprised of individuals that survived their first southbound migration, and 2) broad-scale increase of bird stopover density with proximity to ALAN will be weaker farther along migration routes within seasons as birds attracted to ALAN are disproportionately culled from the population.

We tested these predictions by compiling weather surveillance radar data from previous and ongoing studies for which we quantified bird stopover density near the ground at the onset of nightly migration flight exodus in spring and fall within three broad regions spanning a wide latitudinal extent within North America; the Yucatan peninsula, Mexico (18–20° N latitude, 2 radars, 5 years), the southern coast of USA (25-30° N latitude, 12 radars, 8 years), and the Great Lakes region, USA (40-45° N latitude, 7 radars, 4 years). We fit Boosted Regression Trees to model the relationship between seasonal mean bird stopover density and distance from bright areas (i.e., ALAN radiance from VIIRS measurement >= 26 nW cm^2 sr) in each region separately while controlling for other factors known to influence bird stopover distributions including proximity to coastline, Normailzed Difference Vegetation Index, and landscape composition.

Supporting our first prediction, bird stopover density generally increased with proximity to bright areas during autumn across all regions, but actually reversed in the spring, such that bird density decreased with proximity to bright areas. This is the first evidence of broad-scale bird avoidance of bright areas during stopover. Contrary to our second prediction, the relative response between bird density and proximity to bright areas generally did not differ along the migration route during either season. However, one of two southern-most radars in Mexico showed migrants actually avoided bright areas during autumn.

Our results partially support our hypothesis that light-attracted migrants are selectively culled during their southwards migration in autumn, while a higher proportion of experienced or light-avoiding migrants return north, resulting in the observed avoidance of ALAN in spring and potentially explaining the lower number of bird collisions with lit buildings in spring (Loss et al., 2019). Urban sources of ALAN broadly effect migratory behavior and may have a role in shaping migratory behavior of individual species. This emphasizes the need to understand the implications of ALAN for migratory bird populations.

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Dark skies activities in Thailand

Theme: Society

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This presentation summarize the current and future planned dark skies activities in Thailand. The Thai National Astronomical Observatory (TNO) is located 2500m above sea level with a 2.4m optical telescope. The location of the TNO was suffered from light pollution for the nearby farming, and the home institute for TNO – National Astronomical Research Institute of Thailand has taken actions to help the farmers to replace more dark skies friendly lightings and improved the overall situation.

Thailand is also preparing to establish International Dark Skies Parks, the Department of National Parks has included Dark Sky in its mission statement, we will present the site studies and the plan for trainings and related actions.

Effects of low light levels at night on fish foraging in structured habitats

Theme: Biology & Ecology

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Introduction

Artificial light at night (ALAN) has the potential to change organism behavior and thus modify the outcome of predator-prey interactions. In the case of fish, nocturnal illumination has been shown to flush out some species (Contor & Griffith 1995; Hadderingh et al. 1999), impound their migration (Tabor et al., 2004) and increase the predation risk by attracting both small fish and large predators (Becker et al. 2013). Commonly, a detrimental impact of ALAN on fish was emphasized, but Bolton et al. (2017) showed that nocturnal illumination of high intensity (~160 lx) can be beneficial for some coastal species, as it improved prey visibility and thus increased the consumption of invertebrates. However, it was unclear if fish could still maintain high foraging efficiency in aquatic ecosystems that usually experience significantly lower light levels at night (up to 2.5 lx) (Perkin et al. 2014). In addition, effects of ALAN could be moderated by the presence of a structured habitat (e.g. macrophytes or woody debris) providing prey with a refuge.

Fig. 1: Coarse woody debris is a common habitat type in shallow waters (photo credit M. Czarnecka)

To test the influence of ALAN on foraging efficiency of fish in combination with increased habitat complexity, we conducted laboratory experiments using visually-oriented Eurasian perch (*Perca fluviatilis* L.) and gammarids (*Gammarus fossarum* Koch) as a prey species. We hypothesized that nocturnal illumination of low intensity (2 lx) that often occurs in urban waters would enhance the foraging efficiency of perch compared to dark nights. However, perch during illuminated nights would be less effective predator than at dusk (10 lx). The effect of ALAN would also be mitigated in structured habitats providing a refuge for prey.

Methods

Experiments were conducted in 80 l aquaria. Their bottoms were covered with a 2-cm layer of sand providing a simple habitat structure. In half of the tanks the bottom complexity was increased by the addition of two pieces of woody debris (Ø 2 cm, length: 14 cm, total surface: 752 cm^2 per m^2 of the bottom). Under the natural light cycle, dark night (0 lx) was reached, while under the disturbed light cycle, LED light of 2 lx was provided at night, which corresponded to maximal light levels at a water depth of 30 cm in urban waterways (Perkin et al. 2014). We consecutively used the same perch at dusk and at night in each trial. To avoid the confounding effects of the sequence of tests, we tested one group of perch first at dusk (17.00) and then at night (19.00 on the following day), while the other group was tested first at night (19.00) and then at dusk (17.00 on the following day). 24 h prior to the trial, we placed single fish in the experimental aquaria. Four hours before the trial, the experimental arena was halved by a glass divider to confine the fish in one compartment. 15 minutes before the experiment, we introduced 50 individuals of *G. fossarum* to the empty compartment and allowed them to disperse in the aquarium. Afterwards, the divider was removed and the released fish could prey upon gammarids for 60 minutes. We recorded the course of the experiment with a video camera installed above the aquarium. After completion of the trial, the perch was removed from the aquarium and remained gammarids were counted. We estimated the predatory efficiency of perch based on the number of consumed gammarids during 60 minutes. Based on video recordings, we also determined the fish activity. The number of strikes at prey were manually counted, while % time spent in motion was determined using the video tracking software EthoVision 10.1.

Conclusions

The results of our experiments showed that the foraging efficiency of perch was strongly enhanced by ALAN. The consumption of gammarids by perch significantly increased in illuminated nights compared to dark nights. Moreover, perch at low light intensities (2 lx) were as effective predator as at dusk (10 lx), due to intensification of the activity and attack rates at prey. The presence of woody debris did not decrease the consumption of gammarids in artificially illuminated nights. Woody debris provided an effective refuge only in combination with darkness, as the number of consumed amphipods were lowest at natural night. Hence, our laboratory results suggest that the loss of darkness due to nocturnal illuminations in aquatic ecosystems may contribute to the significant reduction in invertebrate population sizes through fish predation.

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Monitoring and modelling sky brightness changes in SW Calgary

Theme: Measurement and Modelling

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Introduction

With major development projects currently, and very soon, underway on the southwest outskirts of the city of Calgary, Alberta, the time is right to make base-line SQM measurements within and around these future regions of residential, street, and highway, lighting. Several SQM data sets have been acquired spanning several years up to very recent times, covering a wide range of physical extent; inside, outside, and above these development regions. Figure 1 shows the flight path of a light-wing aircraft used to facilitate upward and downward pointing SQM measurements over these regions in May 2019.

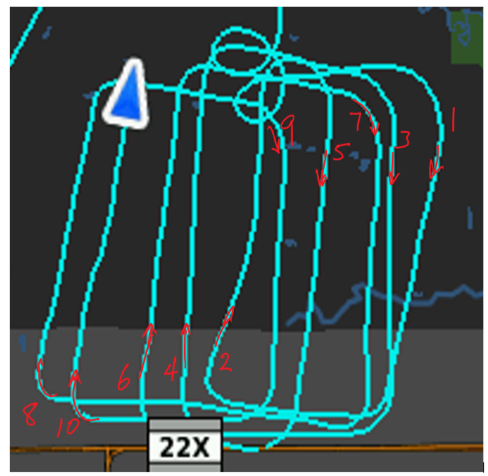

Fig. 1: Sequentially numbered passes of the SQMs 2000 meters above the ground (10,000 ft above sea level).
Odd numbers correspond to a south-ward plane direction. Even numbers correspond to a northward plane di-rection. The general flight plan was to complete consecutive rectangular passes with a general drift away from the city, towards the west.
This image by Phil Langill.

Since 2011, the City of Calgary residential and commercial district street lighting has been almost completely changed from HPS to the current white LED luminaires, as illustrated by the January 6, 2020 image taken by ISS NASA astronaut Jessica Meir, in Figure 2. Using orthorectified techniques, brightness's derived from a set of photographs taken by astronauts aboard the International Space Station will be compared to our SQM datasets allowing comparison to sky glow models. We hope this will allow us to predict future changes to sky brightness above the University of Calgary's Rothney Astrophysical Observatory, the Ann & Sandy Cross Conservation Area (a Royal Astronomical Society of Canada - RASC sanctioned Nocturnal Preserve) and the Weaselhead natural area within the city of Calgary (a potential RASC Nocturnal Preserve).

Conclusion

A unique and historical SQM data set of soon-to-be developed land in southwest Calgary is presented here. Coupled with orthorectified ISS images and skyglow models, it will allow predictions of future changes of sky brightness in darksky protected and sensitive areas. Follow-up SQM measurements after the houses and roads are built will provides quantitative verification of the model predictions.

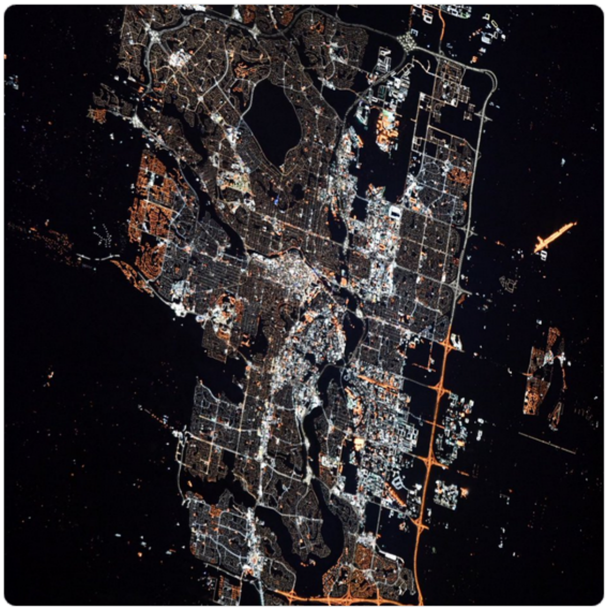

Fig. 2: U.S. astronaut Jessica Meir tweeted this photo of Calgary taken from the International Space Station on Jan. 6, 2020. Jessica Meir / Twitter

Visual task performance, light sources spectra and circadian input reduction

Theme: Health

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Introduction

Visual task is the term given to those activities which require visual perception and are located in a certain place (e.g. reading, writing, drawing, computer working). Spectral power distribution (SPD) affects visual task performance in two different aspects[1]. The first one is related to tasks that require color identification or color discrimination or visibility. The second one relates to circadian regulation. SPD with a high content of blue light affects in a major way circadian disruption. This work compares visual task performance and circadian input in the case of a subject reading a book, in paper support, before bedtime.

Visual task performance in a reading task can be measured with different parameters as visual reading speed, visual acuity, contrast sensitivity function (CSF), etc. The visual performance is measured by means of CSF in this work.

The CSF has been measured in a sample population of young people by using three different lightning systems with different SPD. The values obtained lead us to conclude that the best case is the one with the lowest content of blue in SPD.

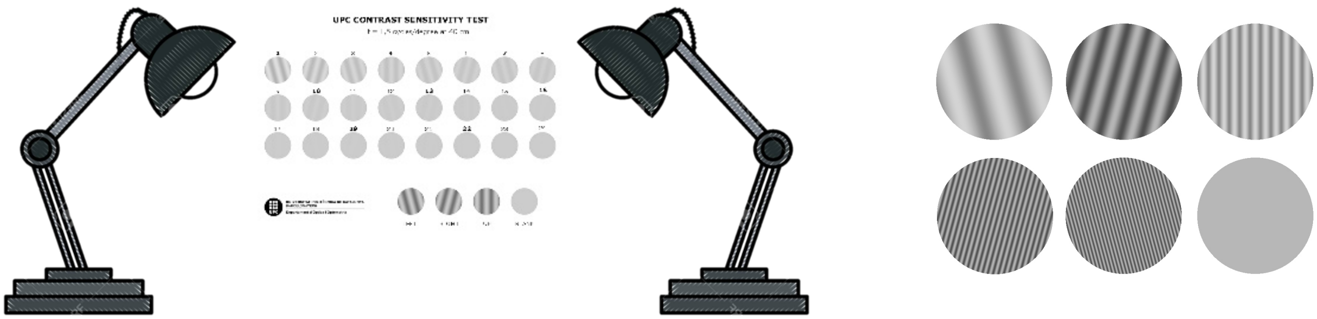
Method

A new test for the CSF has been designed so as to measure the five frequencies: 1.5 cycles per degree (cpd), 3 cpd, 6 cpd, 12 cpd and 18 cpd. Each chart shows 24 patches of decreasing contrast that contain an oriented sinusoidal curve (left, center, right) of the same frequency. A two-LED lighting system illuminates the chart. The CSF charts are presented at 45º from the horizontal at a distance of 40 cm from the viewer, as is shown in figure 1(a). Figure 1(b) displays in detail some patches with different contrast and frequency. Three pairs of light sources with different CCT are used and the lighting characteristics of the device are in table 1.

This test has been applied to thirty subjects (21 women, 9 men) recruited among the students of the Facultat d'Òptica i Optometria de Terrassa. Their ages ranged from 19 to 39 (mean age = 22.53 years, *SD* = 4.61).

Table 1. Illuminace (E) and luminance (L) values at different planes.

CCT (K)	E_{cornea} (lux)	E_{chart} (lux)	L_{chart} (cd/m^2)
3000	144	600	137
4000	140	600	137
6500	131	600	137



(a) (b)

Figure 1. (a) CSF measuring device. (b) Detailed view of some patches

Irradiance values at cornea level for the three lighting systems are exhibit in figure 2(a).

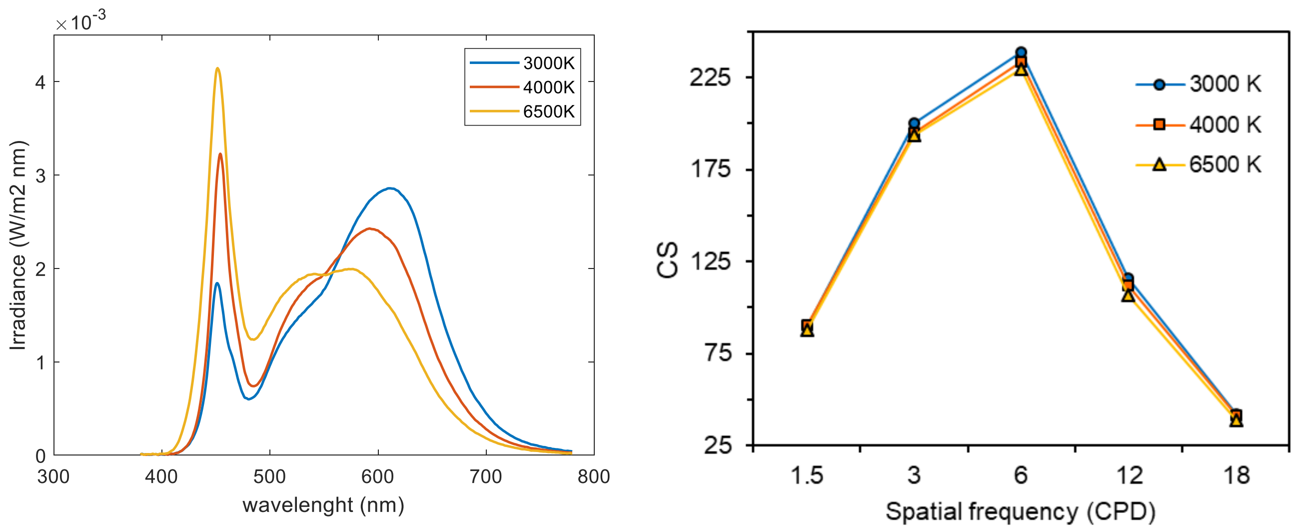


Figure 2. (a) Irradiance at cornea plane of the reader. (b) Mean CSF for each CCT.

Results

A repeated measures analysis of CSF data, accounting for spatial frequency and CCT as fixed factors and pacient as a random factor, was performed. Significant statistical effects were found for both frequency ($p < 0.0005$) and CCT ($p = 0.006$). No significant interaction was found, i. e. the effect of CCT can be considered uniform along frequencies. Figure 2(b) shows that lower CCT are associated with higher CS values and CCT has a small but significant effect on CSF.

Conclusions

The best performance has been obtained in the case of the ligthning system with the lowest content in blue (CCT = 3000 K), the one that coincides with the SPD with the lowest circadian input.

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Application of rendering programs to estimate spectral irradiance and design environments that reduce circadian disruption

Theme: Measurement & Modeling

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Introduction

Artificial light at night is not healthy for us. And, although we know that the best night light is no light at all, humans need artificial light in order to see. This being the case, we must minimize its effect on human health, especially with the disruption of circadian rhythmicity.

Circadian rhythmicity disruption is modelled by means of spectral irradiance that reaches the subject's cornea plane. Blue light is the one that contributes most to the circadian impact and, in order to minimize its effects, it must be avoided or reduced. Unfortunately, most light sources, especially LED bulbs, have an important component of blue light in their spectra. Predicting the spectral irradiance at the cornea in any arbitrarily point in a room requires quantitative models that incorporate the spectral reflectance of the surrounding surfaces as well as the position and orientation of the gaze. We consider that most light the eye receives is not direct and actually it arrives from successive reflections on the furniture and walls of the room. An easy parameter to control in the design of a room is the reflectance of the walls. Walls whose color absorbs blue light, such as red or green will reduce the amount of blue light that hits the eye, thereby reducing the circadian disruption.

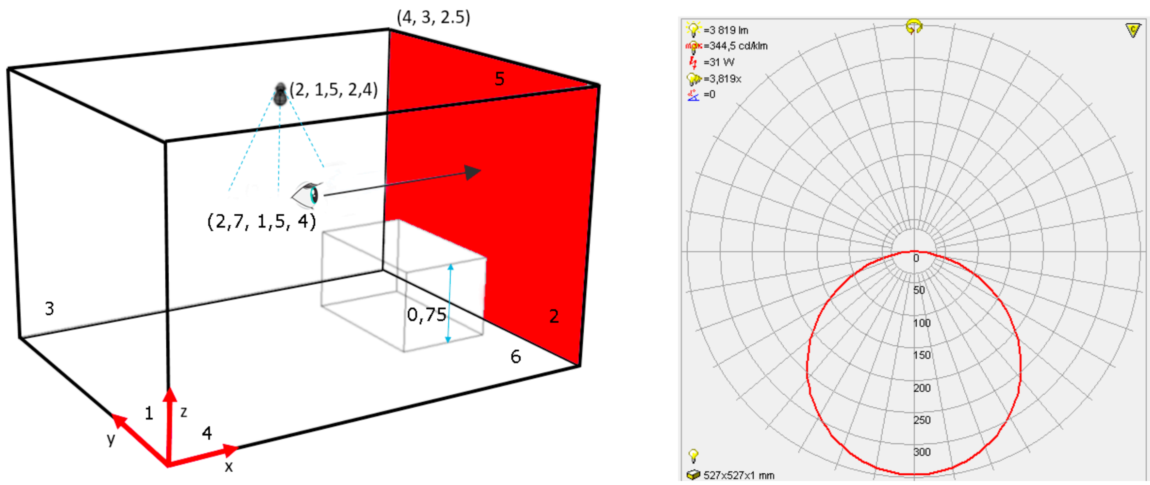
In this work we estimate the spectral irradiance that reaches the cornea of an observer in a room by means of the computer graphics program 3DS Max, Autodesk[1], for creating 3D models, animations and digital images. This program allows us to design a room with it furniture, paint the walls with different colors, situate light sources at different points in the room, establish its angular emission and luminous flux and calculate illuminance anywhere in the room. We have taken advantage of this to compute the irradiance spectrum of the light at the cornea plane of the observer.

Methods

Consider a parallelepiped room with a table, a LED light source, that emits a luminous flux of 1000 lm, and an observer with it gaze pointing perpendicular to wall 2 as displays figure 1 (a). Figure 1(b) shows the angular emission diagram of light source. We estimate spectral irradiance at the cornea plane for two different arrangements of the color of the walls as indicated in table 1.

Table 1. Color of the walls, in R, G, B, coordinates, for two different arrangements.

Arrangement	Wall 1	Wall 2	Wall 3	Wall 4	Wall 5	Wall 6
1	100, 100, 100	100, 100, 100	100, 100, 100	100, 100, 100	100, 100, 100	100, 100, 100
2	100, 100, 100	255, 0, 0	100, 100, 100	100, 100, 100	100,100, 100	100, 100, 100

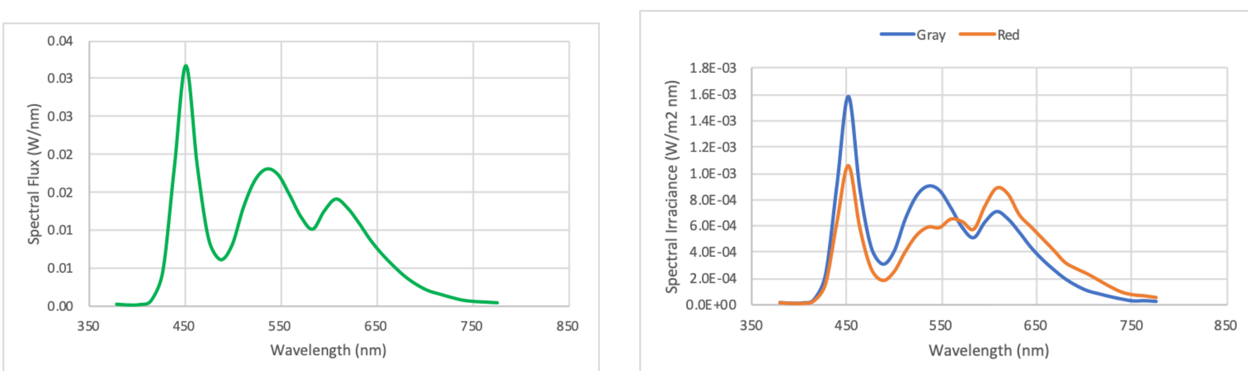


(a) (b)

Figure 1. (a) Sketch of the room with light, furniture, position of the observer and gaze direction. (b) Angular distribution of luminous flux.

Results

Figure 2(a) shows the spectral radiant flux emitted by the source and figure 2(b) displays the irradiance spectra estimate with 3DS max, at the cornea plane, by arrangements 1 and 2 respectively. In arrangement 2 we appreciate a reduction of the spectral irradiance in the blue light zone of the spectrum due to the red color of wall 5.



(a) (b)

Figure 2. (a) Spectral flux emitted by the light. (b) Spectral irradiance at the cornea plane. In blue when wall 2 is gray, in orange when wall 2 is red.

Conclusions

Computer graphic programs may be a useful tool for estimating spectral irradiance in a closed environment. Adequate color in the walls lets us reduce blue light in the irradiance spectra and reduce disruption of circadian rhythms.

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[1] https://www.autodesk.com/products/3ds-max/overview (2020, January 16).

Energy Loss Measurement Using Irish Public Lighting

Theme: Measurement & Modeling

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Introduction

We have been studying light pollution in Ireland using a combination of both ground and space measurements with a focus on light loss from public lighting. As part of this work we have obtained council lighting database information which includes locations, lamp types and wattages for the majority of the 480,000 lights. Currently public lighting consumes over 210 GWh of energy annually and the reduction in energy and carbon use is an important driver to the changeover to LED technology, though it still only accounts for 10% of the emitted lumens.

Irish public lighting is useful for study as it is still predominantly uniform in character, with the majority being provided by either low pressure (LPS) or high pressure sodium (HPS) with roughly 28% and 48% of the total installed lamp Watts, respectively. Additionally, for these lights trimming and dimming practices have not been implemented for the majority of the lighting and thus these lights provide a stable all-night lit environment for both satellite and ground-based surveys. We report on measurements of Irish lighting using satellite data to estimate public lighting emissions as part of an on-going project on wider energy use.

Methods

We performed measurements of the light from Ireland using several different platforms and, using public lighting databases and information from satellite imagery, identified areas where: a) the lighting was dominated by public lighting; b) the lighting used was (almost) uniform in nature with regards to lamp type; and c) obstructions were relatively few. One of the advantages of using LPS data is that the emission is almost monochromatic so the luminous efficacy, i.e. the number of lumens per Watt, is well defined.

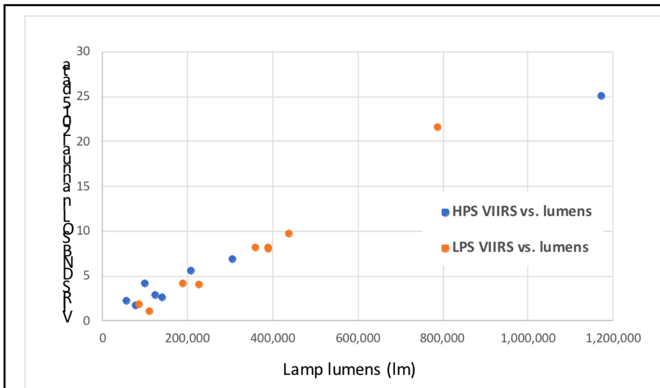

Fig. 1: Data for selected sample regions of LPS light expressed in terms of observed radiance in the VIIRS DNB band against lamp lumens. The data show a strong linear correlation. The number of streetlights in an area ranges from 8 to 99.

We have made initial calculations using simplified assumptions, including Lambertian emission as for these older LPS systems the light is poorly controlled and radiates widely to both ground and sky. Chris Baddiley has shown that Lambertian emission from roads and verges is a good description where obstacles are not present, though the details of the integrated upward emission depends on the nature of the luminaire as well as the surroundings. For a side-entry LPS streetlight he has calculated that the typical emission to the upward hemisphere accounts for approximately 13% of the luminaire's output (Baddiley 2015; Baddiley and Webster 2007). We have used lighting photometry software to obtain the expected lumens for the lighting and corrected for atmospheric transmission using a US62 standard atmosphere model, similar to that used for the World Atlas calculations (Falchi et al. 2016) and find a ratio of atmospherically-corrected emission to predicted luminaire output of a similar value.

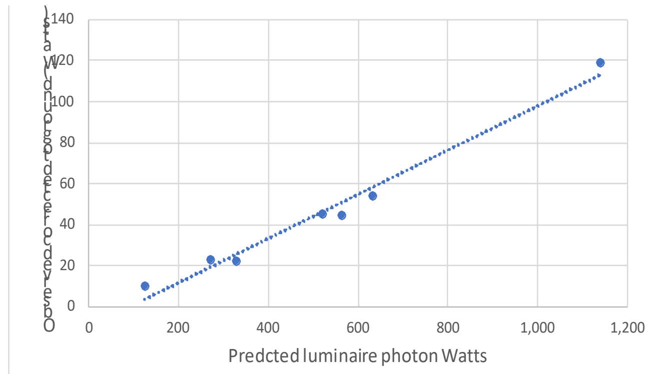

Fig. 2: Data for selected sample regions of LPS light expressed in terms of observed radiance in the VIIRS DNB band (corrected for atmospheric transmission) against calculated luminaire (photon) Watts. The fit shown has a correlation coefficient of 0.98. The number of individual 55W LPS units ranged from 11 to 97.

We will present this work, together with additional data for well-defined lighting samples of HPS and LED lighting at other locations taken with VIIRS DNB, ISS, and LuoJia spacecraft. These data require more careful treatment of details including the spectral dissimilarities of lamp spectra and instrument response. Our work will use these representative results to refine our approach further and the ultimate goal is to use these methods to examine light emission from urban areas in more detail, including to determine the relative proportion of public to commercial and industrial light nationally. Finally, as part of the more general worldwide drive to achieve a reduction in energy and carbon use, the Irish government has committed to moving public lighting towards lower energy use LED luminaires. We will report on the success of Dark Skies Ireland lobbying to have LED lighting with a CCT of 3000K (i.e., "warm white") used as the default for the majority of rural lighting in Ireland, with provision for lower CCT in more sensitive areas such as parks.

Acknowledgements

We thank the various councils and the Road Management Office for making the various public lighting databases available to us. We also express our appreciation to Prof. Li and his team at Wuhan University for obtaining the LuoJia 1-01 data used in this work. This work was supported by grant funding from SEAI Research, Development and Demonstration project 18/RDD/362.

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Computing the number of visible stars in a starry sky

Theme: Measurement & Modeling

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Introduction

It is not obvious how to compute the number of stars visible in the night sky. It depends on the observer eye capability and experience, on the stellar extinction at the different zenith distances, on the sky brightness. The sky brightness of the natural background depends on the airglow, on the atmospheric conditions and on the elevation above sea level of the site. The artificial sky brightness depends on the diffusion in the atmosphere of the artificial lights coming from the light sources surrounding the observing sites, up to hundreds of kilometres away. Here we present a method in order to obtain maps across large territories of the number of stars visible in the upward hemisphere by an average observer.

Building upon the works of Garstang (1989, 1991), Cinzano et al. (2001) introduced a method to map the naked eye star visibility at zenith in large territories. From that, arriving to obtain maps of the average number of visible stars when looking at the night sky hemisphere is not trivial. In fact, the number of star visible depends on several factors, mainly: the limiting magnitude in each direction in the sky (not only at zenith), and this in turn depends on the sky brightness in that particular direction; the stellar extinction in the same direction; the number density of stars visible in a unit of solid angle of sky of given limiting magnitude; the observer visual acuity and experience. The total number of visible stars in a site is given by the integral of the density of visible stars per unit solid angle in the upward hemisphere. The method introduced here can be applied to night-time light satellite data in order to compute maps of the number of visible stars in large territories.

We present in Fig.1, as an example, a map of the number of stars visible by an average observer in standard clear night in Catalonia and surrounding regions with a resolution of approximately 1 km. It is evident that, to have the highest possible number of visible stars, along with a very dark sky, low extinction is needed (in fact, at sea level the highest number is nowhere reached).

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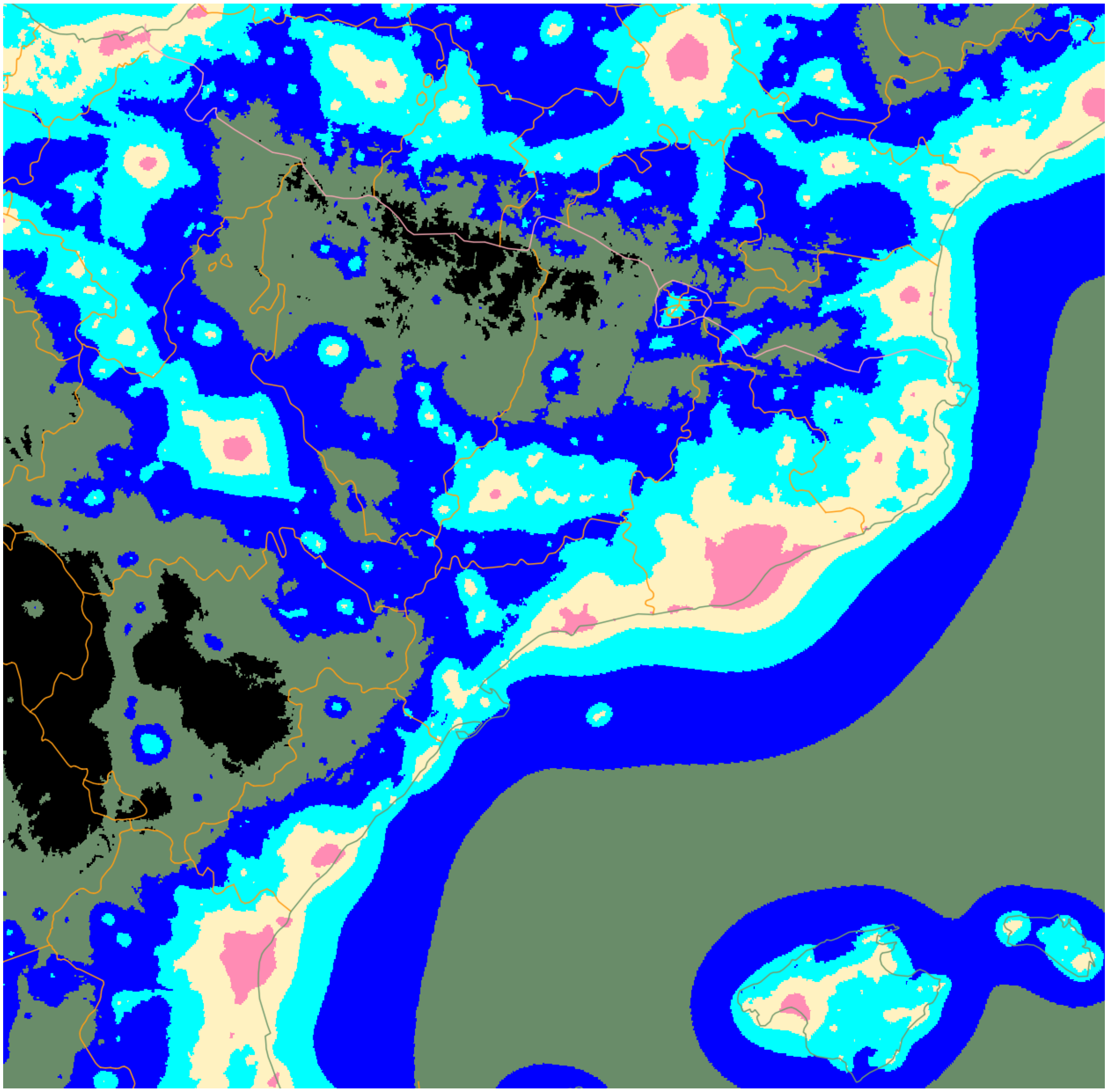

Fig. 1: map of the number of visible stars in Catalonia and surrounding regions. The levels from pink to black correspond to 0-200, 200-400, 400-700, 700-1000, 1000-1300, >1300 stars.

NixNox: the all sky brightness maps project

Theme: Measurements & Modelling

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The NIXNOX project was in its origin a Pro-Am collaborative effort promoted by the Spanish Astronomical Society (SEA) to find and characterize open air observatories with dark skies. The observations were provided by amateur astronomers. It contributes to outreach in Astronomy and it is a help to dark skies fights but it is also a scientific project. Our objectives are to locate sites with dark skies with easy access, to encourage local authorities to preserve them and finally to help citizens to enjoy the starry skies. The NixNox method provides all-sky brightness maps using observations obtained with photometers pointing to selected directions of the sky.

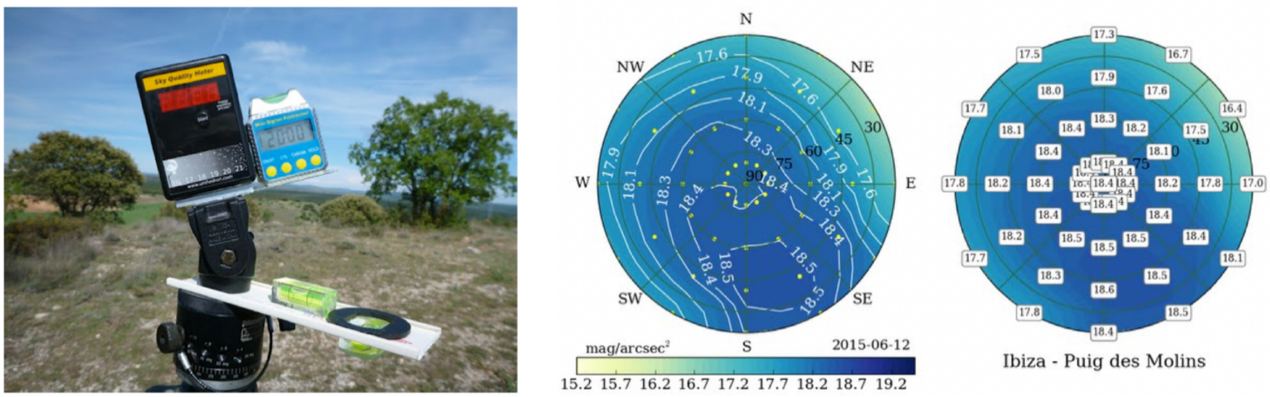

Figure 1. The SQM photometer fitted to a graduated tripod was the original instrumentation used to obtain the data to build the NixNox all-sky brightness maps.

With the help of the STARS4ALL European project we have developed a new photometer that automatically scans the sky and reduces considerably the time and effort to get the data. The TESS Auto Scan photometer (TAS) is controlled by a smartphone app that register the data and create the map on the fly.

During the last years we have obtained all-sky maps in places with not-so-dark skies for research projects. Most of the maps are available at the NixNox webpage and we are working to get the original observations easily available on line (open data) (https://nixnox.stars4all.eu/)

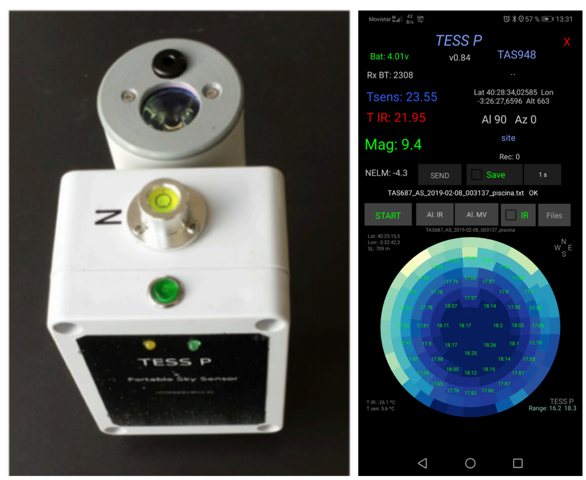

Figure 2. TAS and the smartphone app.

Zamorano, J., Sánchez de Miguel, A., Nievas, M. Tapia, C. (2014) *NixNox procedure to build Night Sky Brightness maps from SQM photometers observations.* https://eprints.ucm.es/26982/

ACTION Street Spectra citizen science project

Theme: Measurements & Modelling

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Street Spectra is one of the pilot citizen science project of the ACTION European project (https://actionproject.eu/). The ACTION (Participatory science toolkit against pollution) project is co-funded by the European Commission under the Horizon 2020 framework, SwafS programme and started on 1st February 2019.

The scientific purpose of Street Spectra is to assess the spectral contents and geographical distribution of light pollution generated by the public lighting systems. With the help of citizen scientists dedicated observers, a database of public observations is being compiled and it will be published as Open Data. In practice, Street Spectra will be a custom made mobile application to help citizens to report observations by taking pictures using their smartphones and a low cost diffraction grating on top of their camera. The resulting spectra will be uploaded into the ACTION servers to allow them to be archived, classified by comparing them with well known categories (atlas of street spectra) and the results mapped.

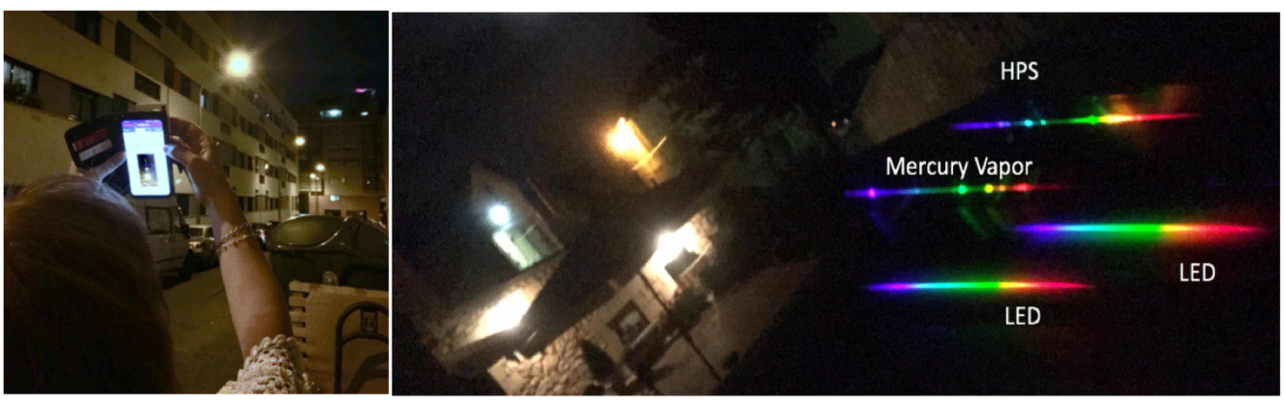

Figure 3. An observer taking a picture of a street lamp using her own smartphone (left) and one of the resulting observations showing the lamps and their spectra for different kind of lights found in the street.

Besides the general manual prepared for citizens, we are writing tutorials to be used at schools with information for teachers and tasks designed to be carried on by the students.

The STARS4ALL night sky brightness monitoring network

Theme: Measurements & Modelling

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Sergio Pascual,[1] Oscar Corcho,[2] Esteban González,[2]
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During the STARS4ALL European project we have developed an open hardware and open software photometer that was designed to monitor the Night Sky Brightness at fixed monitoring stations. TESS-W is a Internet of Things (IoT) device that sends the data via internet using the connection to a local router using wifi. The sky brightness data, and the sensor and sky temperature are received in real time and stored in our repositories. The data and graphs are available on-line (open data).

We describe the TESS-W photometer main features that made this device very useful for long time monitoring. The network of TESS-W photometers around the world and some of the scientifics results up to now are also presented, along with some examples comparing the data obtained from different monitoring stations.

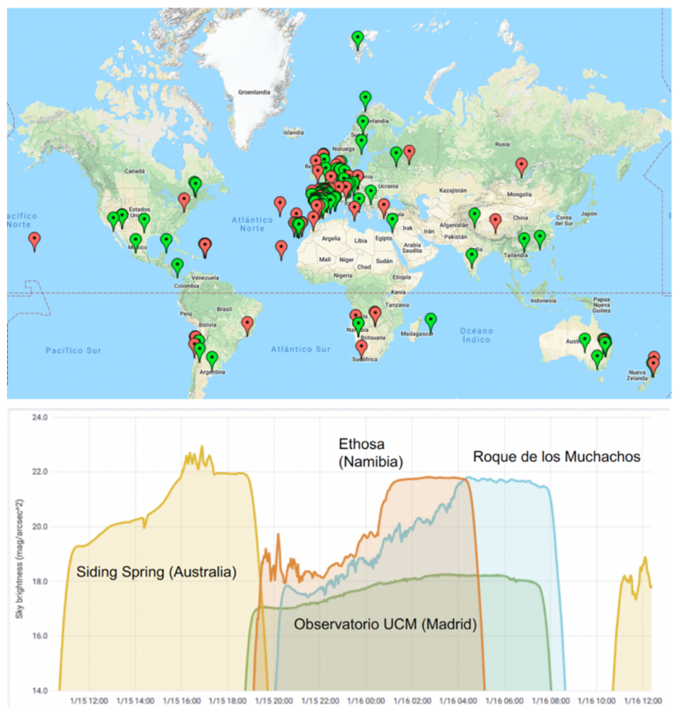

Figure 4. Location of photometers of the STARS4ALL monitoring network and a comparison of measures in different monitoring stations.

Open Data : https://zenodo.org/communities/stars4all and https://tess.stars4all.eu/data/
Real time and archived data graphs: https://tess.dashboards.stars4all.eu/

Estimating the insect attraction of lamps with different color temperatures using ZooLog automatic monitoring system

Theme: Biology & Ecology

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Introduction

Light sensitivity is important for a wide range of animals, especially for flying insects. Their orientation, circadial and annual rhythm depend mostly on natural light patterns. Insects are sensitive to a broad spectrum of light ranging from ultraviolet (UV) to red. Light sensitivity plays an important role in foraging, navigation, and mate selection in both flying and non-flying insects. When insects are exposed to light, they may be attracted to or diverted frotm the source of illumination (positive or negative phototaxis), they may increase or decrease the rate of their activity (Bertholf 1940).

Experimental work supports the idea that color perception exists in insects and that they are particularly responsive to the shorter wavelengths of the visible spectrum and UV light. Varying responses may be related to different light intensities, as well (M. Ashfaq et al., 2005).
In the evening, night-active moths and other insects are highly sensitive to cold (white, blue and ultraviolet) light. The eyes of butterflies are the most sensitive in the range of 380-400 nm, while less sensitive to the longer-wave spectral regions, explaining that the attracting effect of different light sources depends on the spectral composition. Therefore, for example metal halide lamps or LEDs emitting blue or cool white light exert attractive effects for moths 6-10 times higher than those measured for sodium lamps with longer wavelength (warm white or yellow) light (Huemer et al. 2010). In a four choice lab experiment, blue light was more effective than green, orange, or red light. In subsequent experiments testing LEDs emitting peak wavelengths in the blue/violet light range, 405 nm was significantly more effective than 435-, 450-, or 470nm. (Cowan and Gries 2009).

Based on this knowledge, we hypothesize that the spectral composition of the lamps is significantly more important than the range of illumination produced by the lamps. For this we conducted trapping survey using attractive lights with different color temperature. Counting of insects was conducted by using a newly introduced automatic remote sensing method: ZooLog monitoring system, which is an improved version of the Edapholog monitoring system (Dombos et al. 2017).

Methods

We used four Jermy type light traps with lamps of different color temperature (mercury vapour lamp with 4000 K, 3100 Lumen, – used in old street lighting systems and light traps; fluorescent lamp with 6500 K 2850 Lumen – most extensively used in recent street lighting; LED with 4000K 2450 Lumen – used in streetlight modernization most frequently, LED with 2700K, 2450 Lumen – proposed for good lighting). Automatic counting sensors were installed under these Jermy type light traps, which provided data remotely: detection time for each individuals captured, temperature and humidity and a value related to body size (Dombos et al. 2018, www.zoolog.hu).

Bottom of the Jermy light trap, ZooLog sensor ring and data collector have been connected . Image by István Gyarmathy

The traps were established in the University Botanical Garden in Eger, well separated from each other, investigations are being continued throughout the year from dusk to dawn.

Conclusions

Automatic data collection allows the collection of large amounts of data, adequately to be processed and interpreted. We started testing of the system only in the end of 2019, however, preliminary data proved that the automated probes yield data for continuous insect trapping under different color temperature illuminations, thus providing an opportunity to estimate the amount of biomass removed from their habitat in the sampling area, to monitor daily and longer-term activity changes, and to analyze the attractiveness of different color temperature lighting sources. The gathered data are not enough yet to draw conclusions, but we keep collecting the data and in the proposed poster or presentation we can report about our results.

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Light Pollution Mapping from a Stratospheric High-Altitude Balloon Platform

Theme: Measurement & Modeling

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Introduction

The NITELite (Night Imaging of Terrestrial Environments Lite) system is a method of collecting regional scale light emissions data from a latex high-altitude balloon (LHAB) platform. An LHAB reaches altitudes of 25-30km where the nighttime imaging is performed. LHAB missions are relatively low cost (<$2000/flight) and easy to repeat. A NITELite mission collects data with high resolution (<10m/px) color information (RGB) on a regional scale (~50x50km). This system represents an opportunity to fill the data gap between aerial and satellite observations, providing a new source of remote sensing for artificial light at night (ALAN) research (Levin et al., 2020). Nighttime LHAB-based imaging can provide data such as observation of real-time variability, creation of lighting inventories (including the rough identification of lamp types) (de Miguel et al., 2019), monitoring the effects of seasonal changes, documenting events of interest, and exploring the angular dependence of ALAN sources. Preliminary results demonstrate the potential of this method for future ALAN research and understanding.

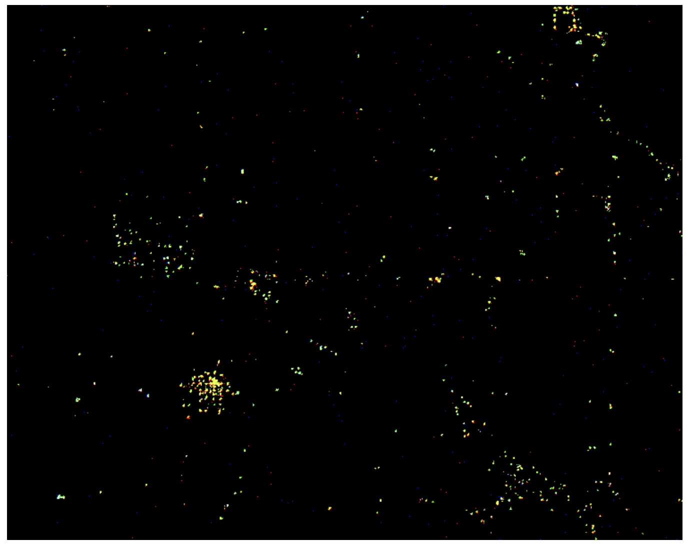

Fig. 1: NITELite image from an altitude of 25km. This 8x6km image shows the small towns of Monterey (lower left) and the Hartz Lake "subdivision" (upper right) in Northern Indiana.

Methods

The NITELite system consists of an imaging system, an IMU and a geo-positioning system encompassed in an on-board computer, and an altitude control system, as well as dynamics sensors, transmitters, and tracking beacons. The imaging system consists of three Basler acA1920-40uc cameras with 1920x1200px resolution in Bayer RGB format. The cameras - one nadir pointing and two off-axis at opposite 21-degree angles - create a single 35x10km imaging footprint at altitude. An On-Board Computer (OBC) logs GPS, accelerometer, gyroscope, and magnetometer data associated with each image. These two systems provide the raw image data and dynamical metadata necessary to perform analysis. The payload is carried by a LHAB tethered to an altitude control system (ACS) capable of altering the rise-rate and thus maintaining neutral buoyancy. This allows for stable imaging with durations of two or more hours.

Sample Results -- Source Classification

Analysis from NITELite missions demonstrates its capacity to discriminate sources of artificial light by lamp type. Figure 2 shows the preliminary analysis of a subset of light sources in the town of Monterey, Indiana and the neighboring Hartz Lake "subdivision". A series of 115 nadir images were obtained from an altitude of approximately 25,000m over a period of 15 minutes (see Fig. 1 for example image). During this period the change in the angular direction to the sources was minimal, reducing the effects of changing viewing angle. These 115 images were grouped in "stacks" of 5, closely spaced in time. Light sources were centroided and photometry was performed on each image/source independently and then averaged within stacks. Shown are the color ratios of 60 sources in a single stack. There is clear separation between the lights in Monterey and newer Hartz Lake subdivision. Further, visual inspection of the locations of the sources confirms that within Monterey, all street lights cluster at the bottom right, while light sources associated with houses, farms, or commercial establishments, form the looser, but well-separated cluster centered around (0.9,0.4).

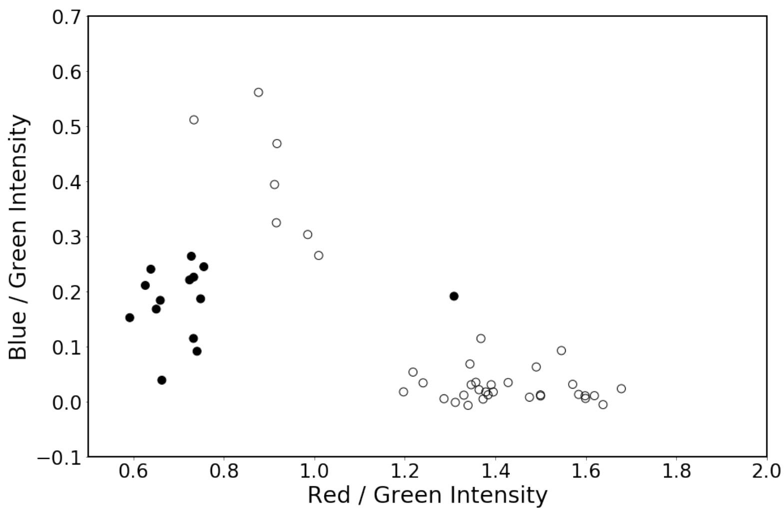

Fig. 2: Color Intensity ratios for light sources in Monterey (open circles) and Hartz Lake (filled circles).

Future Directions

Over Spring 2020 we have flights planned over Chicago and Kankakee (and the surrounding areas). These flights are expected to produce expanded datasets covering a broad range of urban to rural development. In concert with these flights, we will be conducting coordinated ground observations via the deployment of our GONet system of all-sky cameras. A partially automated analysis pipeline is also under development.

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Tracking changes in public lighting

Theme: Society

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Introduction

The influence of changes in public lighting on light pollution has been tracked either with satellite techniques (e.g. Hyde et al., 2019) or by using measurements of the sky brightness (e.g. Barentine et al., 2018). We present here results about the effect of reducing façade illumination and public street lighting with well-known lighting flux on the sky brightness above the International Dark Sky Community Fulda.

Sky brightness changes due to public lighting in Fulda

The city of Fulda with about 68600 inhabitants has always installed an energy saving public lighting, as most of the light sources have been changed to efficient sodium high pressure or fluorescent bulbs. Comparing the light emission using VIIRS data with the city of Flagstaff that has about the same number of inhabitants but was recognized as International Dark Sky (IDS) Community since 2001, revealed that Fulda emits about 2 to 4 times less light than Flagstaff. This was a good starting point for the application process. An inventory of the public lighting was available with the number of luminaires that are switched off during the night. From this data it was possible to derive the amount of light emitted by public lighting and the reduction percentage. On 2 nights (one being the night of WWF-Earth Hour) sky brightness measurements in the city were taken at different observing places with SQMs and a DSLR with the Sky Quality Camera software (Mohar, Euromix). Due to varying cloud cover the switch-off of illumination during Earth Hour could not detected. Besides the reduction of the public lighting at 22:30 by about 18%, the switch-off of the façade illumination especially of the cathedral at 22:00 could be documented. This is much more sustainable and energy saving than the symbolic switch-off for 1 hour during Earth Hour.

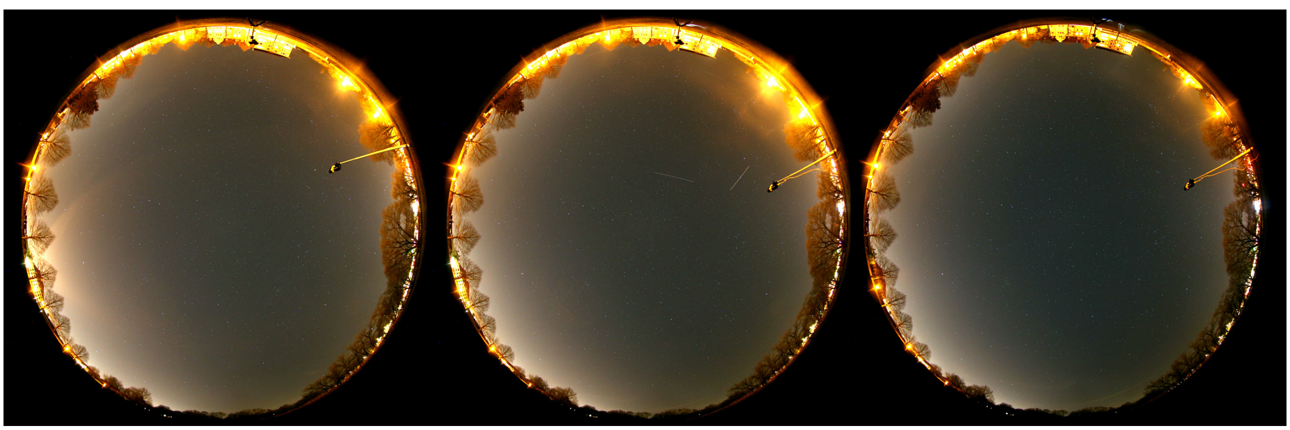

Fig. 1: Allsky pictures in the center of Fulda from 2019, March 29, showing the sky before due to switch-off of the façade illumination of the cathedral at 22:00 (left, the cathedral is on the left), after the switch-off (center) and after the reduction of the street lighting at 22:30 (right). Photos: A. Hänel

Monitoring changes of public lighting with satellite data

The French Parc Naturel Régional de Millevaches in the Massive Central plans the application as an International Dark Sky Reserve. This region was identified from the second Light Pollution Atlas (Falchi et al., 2016) as one of the darkest regions in Central Europe. This darkness was confirmed by sky brightness measurements taken by the author in May 2016 and July 2019.

On a regional map of the park several communities were labeled as “Village Étoilé” by the French Dark Sky Group ANPCEN (Association Nationale pour la Protection du Ciel et de l’Environnement Nocturne). These are villages that reduce or mostly switch off their public lighting. The change of light emission from the small villages was tracked using the application lighttrends.lightpollutionmap.info by J. Stare. Some villages showed a sudden reduction of light emission. A search on the internet showed municipal decisions or press articles about a reduction or switch-off in these villages at exactly the time when a drop of radiance could be observed in the data. Some of the villages reduced their lighting due to the application process as IDSReserve. This confirms that important changes in individual cases can easily be tracked with the VIIRS data.

Therefore this method has been used to track changes of the radiance in some German settlements with well-known changes of their – mainly public – lighting.

Thanks: Lighting data were provided by the RhönEnergie. With the measurements helped: Marc Streit, Sven Melchert, Sabine Frank, Simon Manger, High School Fulda.

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Rock 'n' Roll induced skyglow? The influence of a major outdoor music festival (Lollapalooza, Berlin 2016) on urban night sky brightness

Theme: Measurement & Modeling

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Outdoor music festivals have become very popular in recent years and represent a growing market for tourism. Although some festivals aim to be eco-friendly and sustainable, research on the environmental consequences and the sustainability of festivals is difficult and sparse [1]. In particular, the impact of such events on ecological light pollution [2] and on urban skyglow [3] has not been investigated, yet. In this work, the influence of a major music festival, Lollapalooza Berlin (140,000 visitors) held in Treptower Park, Berlin in Summer 2016, on urban skyglow was investigated for the first time.

Fig. 5 Position of the night sky brightness meter (SQM, see text) near the main stage of the Lollapalooza music festival in Berlin 2016. (Images: A. Jechow, flickr user izillr in public domain http://www.flickr.com/photos/izillr/)

The festival organizers provided access to the festival site during the construction period and allowed to install a night sky brightness (NSB) meter (sky quality meter, SQM). The SQM was mounted directly at the FOH "front of house" tower in front of one of the main stages (Fig. 1). The night sky brightness was monitored over several days including nights before the festival not affected by stage lighting. Before the festival, the minimum NSB was on the order of $L_{SQM,zen} \approx 18.1$ mag/arcsec² ($L_{v,zen} \approx 6.2$ mcd/m²), which is about 25 times brighter than a reference clear sky. During the festival, minimum NSB increased to $L_{SQM,zen} \approx 17.7$ mag/arcsec² ($L_{v,zen} \approx 9.0$ mcd/m), while the maximum NSB reached values of $L_{SQM,zen} \approx 15.7$ mag/arcsec² ($L_{v,zen} \approx 57$ mcd/m), which is about 230 times brighter than the clear sky reference.

Furthermore, all-sky [3] and vertical plane photometry [4] with a calibrated DSLR camera with a fisheye lens was used from a nearby observation spot inside of the park (Fig. 2). Data was analyzed with sky quality camera software (SQC, Euromix, Ljubljana, Slovenia). Measurements were obtained before the festival and during the light check of the festival. Before the festival, the zenith NSB was $L_{SQM,zen} \approx 18.5$ mag/arcsec² ($L_{v,zen} \approx 4.2$ mcd/m), horizontal illuminance was $E_{v,hor} \approx 19.3$ mlx, and the average correlated color temperature (CCT) was 3350 K. During the light check, the zenith NSB was $L_{SQM,zen} \approx 18.1$ mag/arcsec² ($L_{v,zen} \approx 6.1$ mcd/m), horizontal illuminance was $E_{v,hor} \approx 30.7$ mlx, and CCT was 3420 K. Thus, the NSB and illuminance increased by about 50 % and the CCT was slightly elevated during the light check.

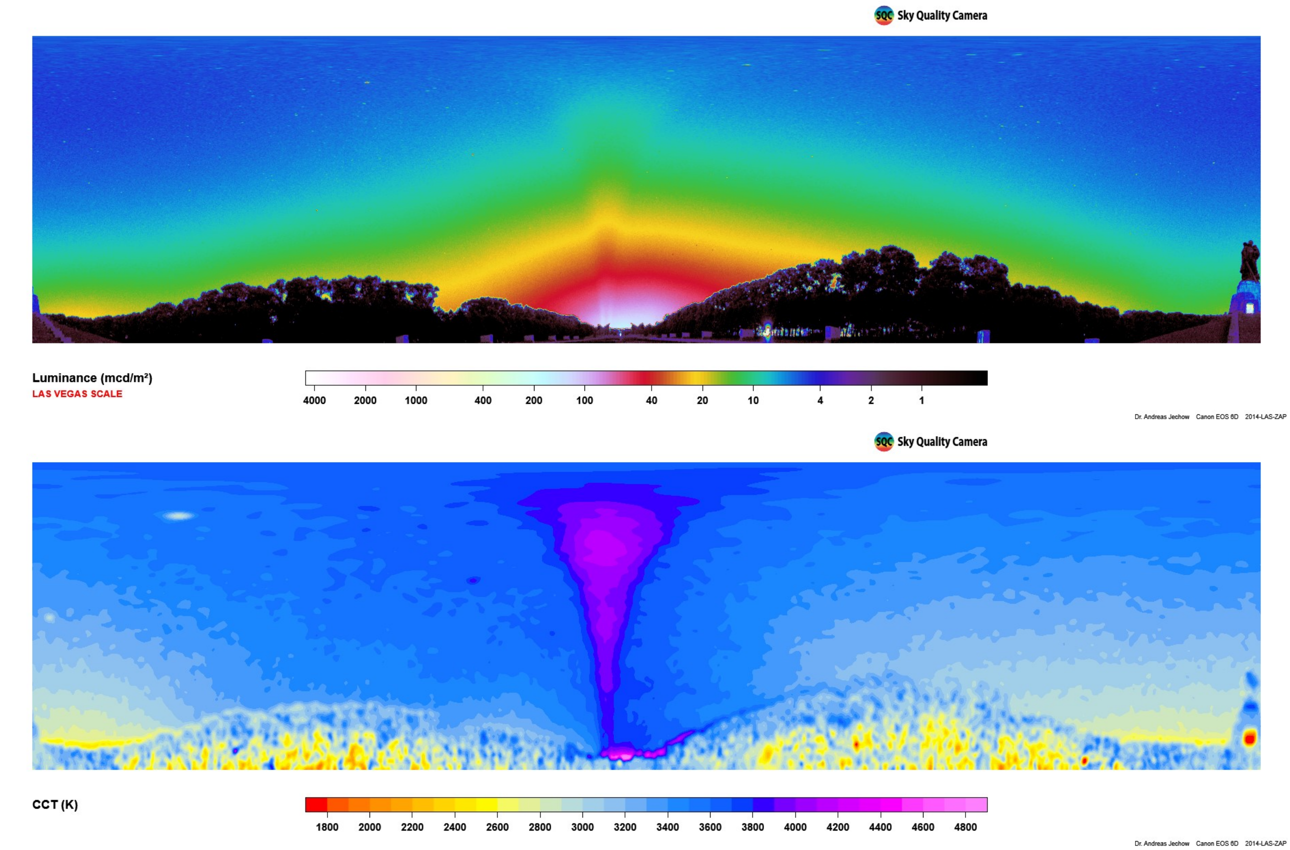

Fig. 6 a) Luminace and b) CCT maps derived from all-sky imaging within Treptower Park, Berlin Germany during the light check of a major outdoor music festival.

Figure 2 shows all-sky data (in cylindrical projection), obtained during the light check for a) luminance and b) CCT. The stage was located between the observation spot and the city center. Thus, the festival lights appear in front of the skyglow of the city center (light dome in Fig. 2 a center). Elevated CCT and luminance can be clearly perceived, particularly the beam towards the sky. These measurements presented here were obtained during clear skies. Furthermore, measurements of the NSB for different weather conditions and natural light situations were performed in summer 2016.

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Exposure to Artificial Light-At-Night and Obesity in a Population Study in Spain

Theme: Health

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Background. Experimental and epidemiological evidence shows that long-term disruption of endogenous circadian rhythms may be associated with a wide range of common diseases, including cancer, cardiovascular diseases and major metabolic disorders such as obesity and type 2 diabetes (Scheer et al 2012, Ward et al 2019, Wegrzyn et al 2017). For humans, the invention of modern electrical lighting has led to expanding human activities over the 24-hour (Kyba et al 2017) and to a disruption of our circadian rhythms, due to mistiming of external cues, particularly light exposure but also by irregular sleep-rest-activity patterns and dietary intake. There is still very little epidemiological information on human populations assessing ALAN and its effects on health based on individual information rather than doing ecological comparisons. We recently published (Garcia-Saenz et al 2018) the only population study conducted to date using an assessment of exposure that incorporates light spectrum and that uses a space resolution of a few metres. An evaluation of the effects of light on health outcomes has moved from measuring only light during sleep to a more global evaluation of exposure to light to periods several hours before sleep or even light during the day.

Objective: We evaluated the association of exposure to artificial light-at night (ALAN) with obesity in a population based study in Barcelona and Madrid, Spain. We applied a novel method for exposure assessment examining visual light and blue light spectrum.

Methods. We examined information on 1129 randomly selected subjects (582 men, 547 women) from Barcelona (n=572) and Madrid (n=557), enrolled in 2008-2013 in a population-based cancer case-control study in Spain (Castaño-Vinyals et al 2015). For this analysis we included only information from the random sample of population controls. Participants aged 20 to 65 were interviewed by study personnel and extensive information was recorded in a structured questionnaire on numerous factors including residence, indoor light, lifestyle factors, socioeconomic factors, chronotype, self-reported weight and height at time of the interview and one year earlier. After the interview, hip and waist circumference was measured by trained study personnel. We examined excess-weight (Body Mass Index (BMI >=25) and abdominal-obesity (waist-hip ratio >0.85 women, >0.90 men). The study was approved by the Ethics Committee of all participating centres and all subjects provided written informed consent.
Indoor-ALAN information was obtained through questionnaires. We evaluated indoor ALAN through the MCC-Spain questionnaire where it was defined as the level of light in the bedroom during sleeping time. This was a subjective measure requested during the face-to-face interview using a four-digit Likert scale: a) total darkness, b) almost dark, c) dim light, and d) quite illuminated.
Outdoor-ALAN was analyzed using images for 2012-2013 from the International Space Station (ISS) including data of remotely sensed upward light intensity and blue light spectrum information for each subject's geocoded longest

residence. For the evaluation of outdoor ALAN, we used images of Madrid and Barcelona (ISS030-E-82052, 2012) and (ISS035-E-23385, 2013), respectively. A description of the methodology used to calibrate and inferring the observed lighting type from the RGB signature see the procedure described in Sánchez de Miguel 2017. We also calculated an index of outdoor blue light spectrum using an approach described in Aubé et al. (2013) to calculate the melatonin suppression index (MSI) at each pixel of the image.
We calculated Odds Ratios (ORs) and 95%confidence intervals using logistic regression models and adjusted for age, sex, education, and menopause (women). We further adjusted for additional residential characteristics and sleep.

Results. Subjects who slept in "quite illuminated" bedrooms compared to those sleeping in total darkness tended to be more overweight with an increase in risk of about 50% (excess weight OR=1.52, 95%CI 0.83,2.78) while a less pronounced association was observed for abdominal obesity (OR=1.25, 95%CI 0.60,2.61). These increased risks were observed only in women.
Exposure to outdoor ALAN in blue light spectrum tended to be associated with overweight (OR for highest tertile of blue light compared to lowest: 1.29, 95%CI 0.90,1.86) but confidence intervals were wide. No association was observed for abdominal obesity. Results were similar when examining separately overweight (BMI 25 to 30) and obese (BMI above 30). Results on excess weight and blue light spectrum exposure was observed in both men and women. There were no associations observed with indices of visual light.

Conclusion. In this population-based study we found an indication that exposure to indoors ALAN and outdoor blue light spectrum may be associated with overweight but results were not fully consistent between sexes.

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DiCaLum 3.0 – metrics and conversions

Theme: Measurement & Modelling

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DiCaLum is a set of GNU Octave routines which can be used to convert the RAW images of commercial digital cameras to calibrated radiance distributions. The software has been used for the designation of international dark sky places worldwide and also for surveys in Hungarian national parks. The results of these measurements (see the presentation by Pusztai-Eredics et al.) forced us to rethink the practice had been used in the processing of digital camera images. The use of the green channel alone, even if some correction is given by the red and blue channels, results in significant errors. The main source of errors is the spectral mismatch of the camera sensitivity curves respect to the calibration devices. When the camera measurements are converted to other units, the systematic errors are further increased.

The latest version of our software, DiCaLum 3.0, includes a conversion to a metric which is connected to the real spectral sensitivity of the cameras. The results are given in band-averaged spectral radiance in all the colour channels (RGB). We provide the steps of calibration and the possible conversions to different units and the errors of the procedures. We also demonstrate that some of the conversions used in the literature are not grounded well.

DiCaLum has no graphical user interface as it is rather a set of routines and libraries. However, we present possible pipelines to process data. These pipelines include extra steps, e.g. for creating whole sky images from mosaics of multiple images (which is routinely used in our surveys), procedures to easily provide LaTex reports of the measurements. We also provide extra routines to convert the calibrated images to colour corrected photos. The colour correction is based on spectral measurements of the sky in real conditions. We have to note that the colour schemes used in astrophotography usually do not match the real colours of the night sky. The correct colour conversion also helps to distinguish between natural sources (e.g. aurora and airglow) and light pollution.

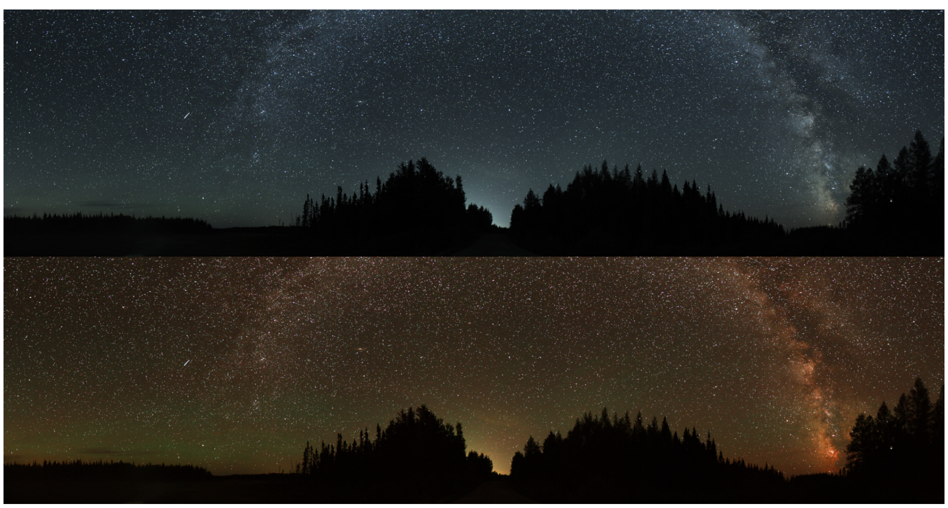
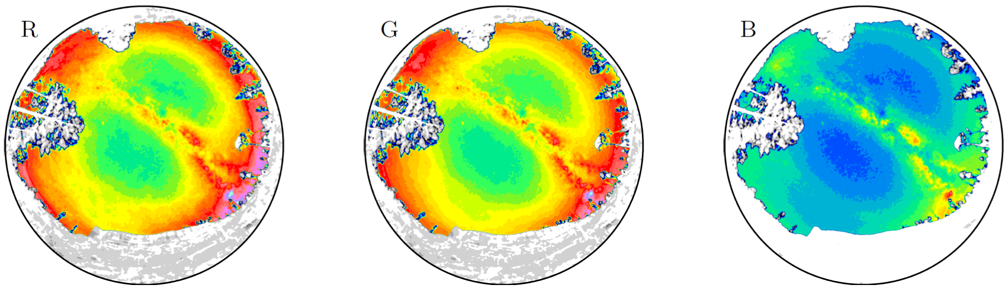
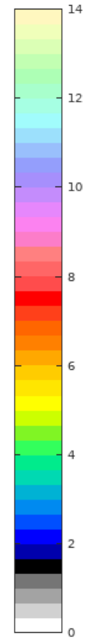


Fig. 1: Astrophotographer style (top) and true colour version of the same photo. Colour correction is based on spectral measurements

In this talk, we also present recommendations for sky quality surveys, measurements for dark sky places proposals

Gila Cliff Dwellings National Monument





	R	G (mpsas)	B
z<5°	4.07	3.97 (21.42)	2.75
z<15°	4.24	4.19 (21.42)	2.97
z<30°	4.24	4.49 (21.42)	2.97
min	3.69	3.69 (21.50)	2.47
max	11.56	11.02 (20.31)	7.57

Units given in $nW/m^2/sr/nm$ (and mpsas for G)

Observers: Zoltán Kolláth & Blake Metcalf

Date: Oct 20/21 2019

Coordinates: 33.229178, 108.267261

Fig. 2: Generated LaTeX based report by DiCaLum

and designations. The unit ($nW/m^2/sr/nm$) used in DiCaLum 3.0 is in the order of 2 for the clear sky at dark locations and in the order of 1 for cloudy skies at remote locations. Thus it can be used as a natural unit for light pollution surveys. We also propose the abbreviation of 1 *dsu* (dark sky unit) for this unit which can be used to communicate the results to the general public.

Acknowledgements: The project is supported by the European Union and co-financed by the European Social Fund (Grant no. EFOP-3.6.2-16-2017-00014; Development of international research environment for light pollution studies).

Nachtlicht-BüHNE. Citizen Helmholtz Network for the Research of Nocturnal Light Phenomena

Theme: Society, Measurement & Modeling

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Mapping and monitoring light sources and their emissions are important for proposing and controlling lighting regulations. Looking at light emissions detected by the VIIRS Day/Night Band (DNB), we previously found on average that the lit area increased by 2% per year globally between 2012 and 2016 (Kyba et al., 2017). However, to date no information is available about how satellite radiance observations at the top of the atmosphere relate to the number and type of light sources on the ground. Similarly, there is little information about how much public, private, and commercial lighting each contribute to overall emissions. The only type of lighting for which data is frequently data available is for inventories of public street lighting.

Most light emission reduction measures have been focused on street lighting, but perhaps we are missing the big picture when focusing only on these lighting types? Most existing studies estimate their contribution to be less than 50% of total emissions (Cachia, 2018; Hiscocks & Guðmundsson, 2010; Kuechly et al., 2012; Luginbuhl, Lockwood, Davis, Pick, & Selders, 2009; McEnroe, 2019; Ruhtz, Kyba, Posch, Puschnig, & Kuechly, 2015; Wuchterl & Reithofer, 2017). In a global survey in 2018, lighting experts reported numerous problematic private light sources (Schulte-Römer, Meier, Dannemann, & Söding, 2019).

This motivated us to develop a methodology and app for mapping all visible outdoor lighting sources in set locations, in close coordination with the citizen scientists. Our project called “Nachtlicht-BüHNE” (Citizen-Helmholtz Network for the Research on Nocturnal Light Phenomena) is one of three projects funded via the "CitizenScience @ Helmholtz" initiative from the German Helmholtz Association. Within the project, we are developing a co-design process for app-based citizen science projects. Two pilot apps on the topics light pollution and meteor research are being created in cooperation with scientists of German Space Agency (DLR), German Research Centre for Geosciences (GFZ), and the Helmholtz Centre for Environmental Research (UFZ.).

From advertising signs to illuminated windows - everything that is artificially lit in the nocturnal environment along transects walked by Nachtlicht-BüHNE participants will be collected through the app. We aim to cover at least three study areas of 2km² each. This should be large enough to quantify how radiance values observed by the VIIRS-DNB relate to light sources on the ground.

Our main field campaign is planned for autumn 2020, but preliminary tests [Fig. 1] have already been conducted and analyzed (September 2019 and January 2020). Our poster will present an overview of the two applications.

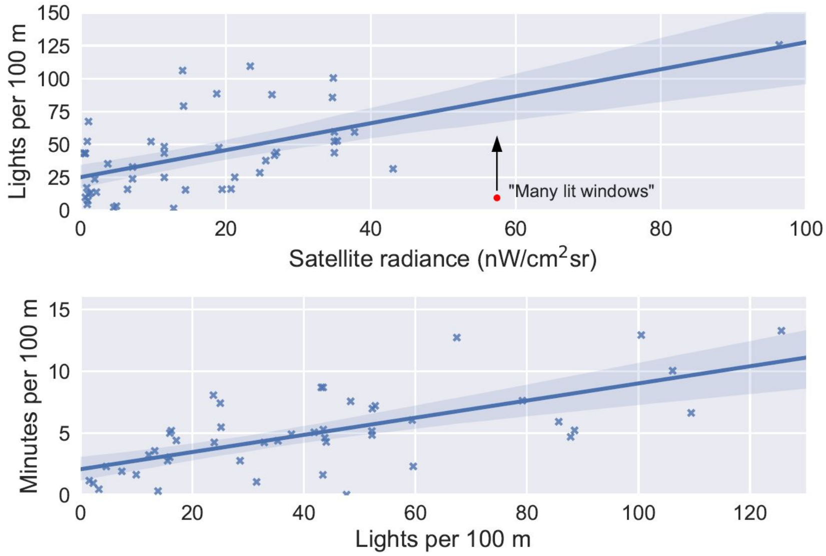

Fig. 1: Results of the first September 2019 trial. Already just one street segment and its number of luminaries correlated to the much bigger pixel emission value of the VIIRS DNB. The average time for participants to walk along their transect was eight minutes per 100 meter.

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Physiological effects of light pollution in a freshwater fish

Theme: Biology & Ecology

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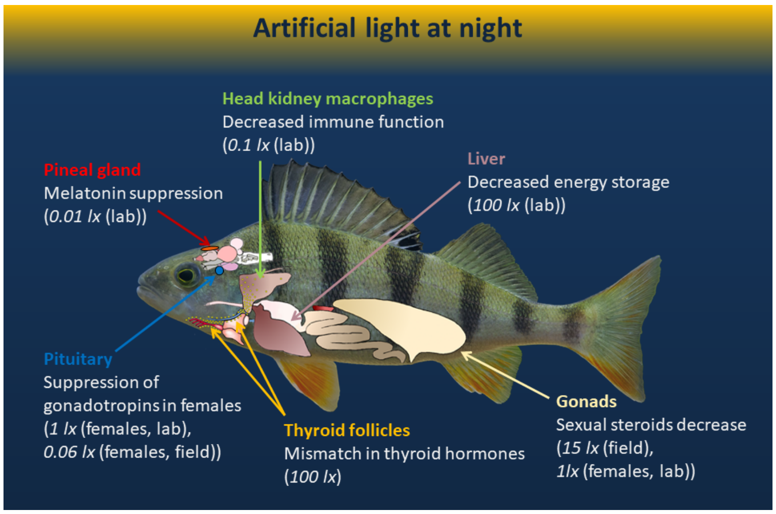

Fig. 1: The physiological effects of light pollution in different organs of the Eurasian perch (*Perca fluviatilis*). Light intensities shown in italics indicate the lowest average values on the water surface, where a significant effect was detected ($p < 0.05$). In laboratory studies, light intensities were tested in logarithmic steps between 0.01 and 100 lx.

Introduction

Freshwaters are frequently exposed to artificial light at night (ALAN) because human activity – the source of ALAN – accumulates around freshwaters. Urban freshwaters experience direct local illumination at intensities >10 lx by street lamps, buildings along the shore, or boats. In addition, skyglow indirectly illuminates rivers and lakes in and around cities and even in rural areas across the entire water surface, although at much lower intensities (<1 lx).

These environmental changes of day-night cycles may affect the diurnal rhythm of freshwater organisms, such as fish. The nocturnal production of melatonin serves as an endocrine time-keeper in all vertebrates including fish. Since melatonin production is directly inhibited by light, ALAN suppresses the natural nocturnal melatonin production, thereby affecting many other physiological processes controlled by daily changes of light and darkness. These processes include the production of other hormones (e.g. stress, reproductive, or thyroid hormones) as well as health-regulating mechanisms such as the antioxidative defense system and the immune system.

In fish, melatonin can be suppressed at very low light intensities and is reduced in a dose-dependent manner. However, thresholds vary among species, and depend on temperature and habitat-specific sensitivity to light color (Grubisic et al., 2019). Implications of ALAN on other physiological processes are rarely quantified.

Our experiments

We exposed Eurasian perch (*Perca fluviatilis*) to nocturnal illumination of 0.01 lx, 0.1 lx, and 1 lx for two weeks in controlled laboratory experiments. We measured melatonin suppression (Kupprat et al., *under revision*) and proxies informing about the status of the immune system, antioxidative defense system, thyroid metabolism and reproductive processes. To assess responses of the immune system and thyroid metabolism we performed a second laboratory experiment involving higher night-light intensities of 1 lx, 10 lx, and 100 lx. Finally, effects on the reproductive system were studied in a field experiment with exposure to 0.06 lx (average illumination at the water surface) in a large lake enclosure facility (www.lake-lab.de). Illuminated treatments in both laboratory and field experiments were compared to controls without artificial illumination.

From our results, we conclude that skyglow causes physiological changes in fish by suppressing melatonin production at an illuminance as faint as 0.01 lx. The effects of ALAN on the health status and other endocrine processes were however surprisingly weak, although some effects were measured at higher illuminance levels (>10 lx). Reproductive hormones did not vary in males in the laboratory experiment, whereas small changes occurred in females in the field experiment.

Our experiments complement previous work on the effects of ALAN on Eurasian perch (Brüning et al., 2016, 2018a; Brüning et al., 2015; Brüning et al., 2018b) and provide a comprehensive understanding of the physiological sensitivity of this freshwater fish towards ALAN. In summary, 1) nocturnal melatonin suppression is highly susceptible to ALAN, 2) health associated processes are less responsive, 3) thyroid metabolism is affected by ALAN only at high intensities, and 4) effects on reproductive processes seem to be sex-specific. The sensitivity of behavioral traits towards ALAN as well as the effects of long-term exposure and the combination of ALAN with other environmental factors remain to be investigated.

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Measuring the contribution of street lighting to urban light emissions

Theme: Measurement & Modeling

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Introduction

In both skyglow research and light pollution activism, street lighting is often treated as if it is the dominant (or even only) source of light emissions. Estimates of the contribution of street lighting to either total emissions or total skyglow vary wildly, from a low of 12% based on a lighting inventory (Luginbuhl et al. 2019) to a high of 80-100% in Galicia based on skyglow temporal changes Bara et al.'s (2019). Whatever the fraction is, it is likely changing rapidly with the widespread adoption of LEDs in outdoor lighting, and especially street lighting conversions. We set out to design an experiment to directly measure the contribution of street lights to satellite imagery.

Methods

The city of Tucson, Arizona, USA intentionally altered the output of their streetlight network over 10 consecutive nights in March and April, 2019. The city uses a control system that allows each lamp to be set independently, and each lamp can be queried to report how it was set for a given night. Light emissions were observed with the VIIRS Day Night Band (DNB) satellite radiometer in the 500-900 nm range. We examined both the total city light emissions and the emissions from areas on a 10 km^2 hexagonal grid on six clear nights. A forested area beyond a nearby mountain range was used to correct the DNB dark offset, and nearby communities were used as "standard candles" to correct for differences in gain and atmospheric extinction.

Results

We observe a strong relationship between the corrected satellite radiance and the streetlight power (Fig. 1). This makes it possible to extrapolate to zero power (i.e. predicting what the satellite would observe if all of the streetlights were turned off). We conclude that on a standard night after midnight, City of Tucson streetlights are responsible for only 13% of the total light emission from within the city administrative boundaries. Tucson dims most streetlights at midnight. We conclude that if the city did not

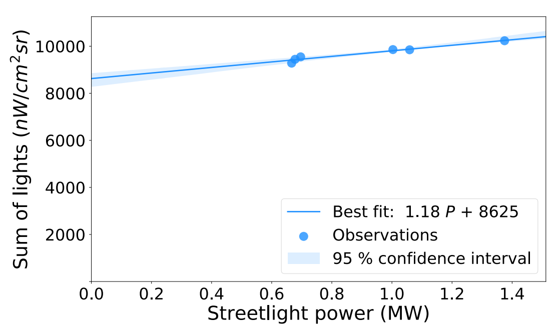

Fig. 1: Comparison of corrected satellite radiance to streetlight power. A linear fit is shown along with the 95% confidence interval. (Fit is to kW, not MW.)

apply dimming after midnight, streetlights would be responsible for 18% of the total light emissions.

Both the contribution of street lights to total light emissions and the relationship (μ) between streetlight power and observed radiance varied throughout the city (Fig. 2). In areas with tall buildings (green and blue hexagons in 2A), the slope μ is much smaller than in suburban areas with short houses set back from the street (yellow hexagons in 2B). In addition, the contribution of street lights to total light emissions is much lower in more commercial areas (<10%) compared to more residential areas (>20%). Pearson correlations coefficients in the individual hexagons are in most cases in the range 0.7-0.95 with $p<0.05$ for over half of the hexagons.

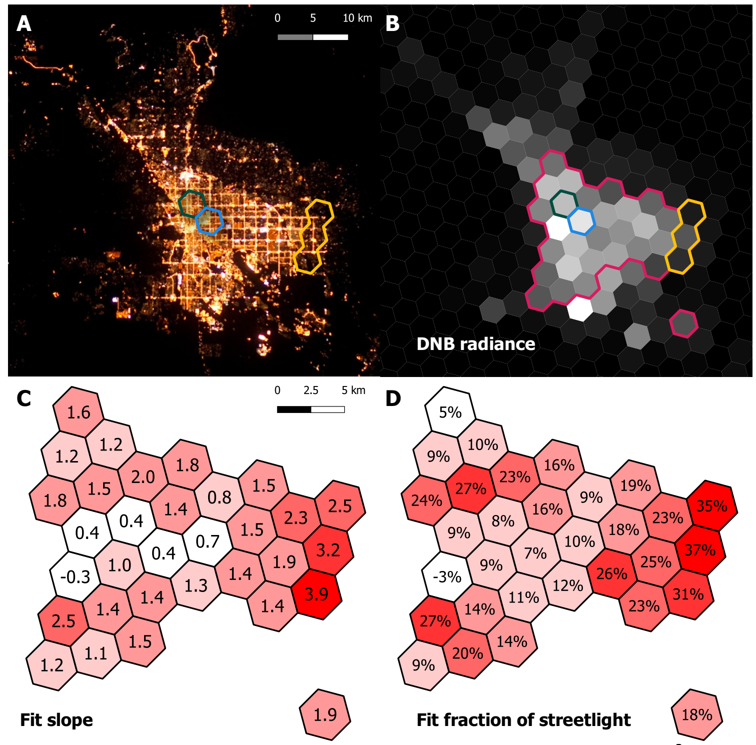

Fig. 2: Analysis of Tucson dimming experiment at 10 km^2 scale. (A) Astronaut photo ISS030-E-183805 of Tucson from 2012 (before retrofit to LED). (B) Average DNB radiance and outline showing the hexagons used in the spatial analysis (red outline). (C) Fit slope μ for each hexagon (cf. Fig. 1). (D) Best fit fraction of street light emissions in each hexagon.

Conclusions

We have demonstrated that cities with smart lighting controls can use those controls in a systematic experiment in order to determine the fraction of light emissions from the city that are due to street lights. Beyond the academic and environmental relevance, this technique could also be used for a city to prove to a lighting provider that they are applying dimming, without the need of pole-by-pole metering. If a city was to vary their light output from night to night by about 20%, it would make it possible to track long-term changes in the relationship between public and private lighting. These results suggest that skyglow modelers and dark sky conservationists should consider putting more focus on light sources other than streetlights, especially in places that have already installed full-cutoff lighting.

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Coral reefs spawning desynchronization and gametogenesis developmental changes under ecological light pollution (ELP)

Theme: Biology & Ecology

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Coral reefs represent the most diverse marine ecosystem on the planet, yet they are undergoing an unprecedented decline due to a combination of increasing global and local stressors. Despite the wealth of research investigating these stressors, "ecological light pollution" represents an emerging threat that has received extremely little attention in the context of coral reefs, despite the potential of disrupting the chronobiology of coral reef organisms. Scleractinian corals, the framework builders of coral reefs, depend on lunar illumination cues to synchronize their behavior, reproduction and physiology, while light pollution may mask and lead to disruption or a-synchronization of these bloggable process. In the recent years, we aimed to understand the broader impacts of light pollution on the reproductive ecology of Scleractinian corals, and more specifically assess how light pollution affects both ecological (spawning synchrony, recruitment and connectivity) and organismal (reproductive phenology, physiology and gene expression) responses in Scleractinian corals. The success of coral reefs and the persistence and recovery of healthy reefs is highly dependent on successful gamete production, fertilization, development of viable offspring and survival of new recruits. In scleractinian corals, "broadcast spawning" is the dominant form of sexual reproduction. Broadcast spawners are either gonochoric or hermaphroditic and can release their gametes independently or simultaneously. Representatives of the alternative reproductive mode, "brooders", can also be gonochoric or hermaphroditic, however their oocytes are fertilized inside the coral polyp prior to development into a swimming larvae. Both reproductive modes are dependent on a phenology, with a cycle that can occur yearly, seasonally or monthly. The reproductive phenology depends on the species and environmental condition, with repeated yearly episodes associated with broadcast and brooder spawning representing a classic example of a periodic biological rhythm. This rhythm that leads to spawning in synchrony, is thought to be controlled by both an exogenous (i.e. environmental) and endogenous (i.e. biological/circadian) clock. For circadian clock oscillations to function, an animal should be able to perceive geophysical cycle information from its surrounding environment and adapt to its biorhythm. For corals, the moon phase and moonlight are key imperative cues with biophysical evidence showing that corals exhibit photoreception in the blue region of the light spectrum and are extraordinarily sensitive to blue spectra matching blue moonlight irradiance levels.

Recently, we aimed to determine whether light pollution affects the reproduction timing and hormonal secretion before, during and after spawning events, two corals species from the Indo Pacific *Acropora digitifera, Acropora millepora* were tested in the Philippines under Blue LED (420-480 nm, 10000K), White LED's (400- 700 nm, 6000-6500K) and Ambient conditions over a period of four months. The two-species showed clear pattern regarding their spawning timing behaviour. As most of the colonies under the ambient light released their gametes into the water, the corals that were exposed to the light pollution treatments with the two LED's did not show spawning behaviour resembling the Ambient coral colonies. Furthermore, the results gamogenesis development using histological sections showed significant differences in the egg count, temporal changes in oocyte and spermary development and in the mean geometric diameter of the gametes. Those are the first evidence which show a direct link between light pollution on gametogenesis changes and spawning behavior in broadcast spawner corals. Overall, our research shed light on the emerging threat of light pollution and the impacts on the chronobiology and ecology of Scleractinian corals, and we hope that our data will help us formulate specific management implementations to mitigate its potential harmful impacts.

Artificial light at night erases positive interactions across trophic levels

Theme: Biology & Ecology

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Introduction

Artificial light at night (ALAN) is one of the most recently recognized sources of anthropogenic disturbance, with potentially severe effects on biological systems (Gaston 2018). Despite some recent advances, current and future effects of ALAN on structure and functioning of whole ecosystems is still far from being accomplished. Of concern are the almost unexplored effects of night light pollution on marine environments and coastal habitats, which are already experiencing a wide range of anthropogenic disturbances (Davies et al. 2014). Among marine ecosystems, high shore habitats are those more likely to be impacted by ALAN, due to a more intense exposition to outdoor nocturnal lightings (mostly from lamps along coastal streets and promenades, or within harbors, ports and marinas) (Maggi and Benedetti-Cecchi 2018).

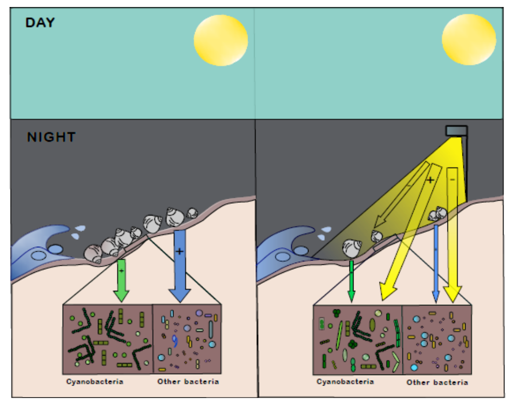

Fig. 1: ALAN (artificial light at night) erased facilitation by grazers on diversity of epilithic bacterial biomes, with an overall increase in cyanobacterial and a decrease in other (mostly heterotrophic) bacterial diversity

Methods

We performed *in situ* nocturnal manipulations of a direct source of cold white LED light and presence of herbivores in a Mediterranean high-shore habitat, to assess the interactive effects of light pollution and grazing on two key functional components of the epilithic microbial community (the cyanobacteria, as the main photoautotrophic component, and the other bacteria, mainly dominated by heterotrophs) developing on rocky shores.

Results

Results showed an unexpected increase in the diversity of epilithic bacterial biofilm at unlit sites in the presence of grazers, that was more evident on the other (mainly heterotrophic) bacterial component, when giving weight to more abundant families. This effect was likely related to the mechanical removal of dead cells through the grazing activity of consumers. ALAN significantly modified this scenario, by reducing the density of grazers and thus erasing their effects on bacteria, and by increasing the diversity of more abundant cyanobacterial families. Overall, direct and indirect effects on ALAN resulted in a significant increase in the diversity of the photoautotrophic component and a decrease in the heterotrophic one, likely affecting key ecosystem functions acting on rocky shore habitats (Maggi et. al *in press*).

Conclusions

ALAN may represent a threat for natural systems through the annihilation of positive interactions across trophic levels, potentially impairing the relationship between biodiversity and functioning of ecosystems and interacting with other global and local stressors currently impinging on coastal areas.

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ALAN increases consumption rate of plants by snails in freshwater ecosystems

Theme: Biology & Ecology

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Abstract

Exposure of natural environments to artificial light at night has dramatically increased due to the development of urbanized area and transport infrastructures during the past decades (Gaston et al., 2015; Hölker et al., 2010). Nocturnal light can affect plants in many ways including altering of the direction of growth, flowering times and abundance and the efficiency of photosynthesic processes (e.g. Aube et al., 2013, Bennie et al., 2016 and 2018). These individual impacts result in changes in patterns of abundance and distribution of species, structuration of communities and functioning of ecosystems (e.g. Bennie et al, 2017). However, mechanisms by which artificial light at night may act on communities remain essentially unknown (Knop et al., 2017; Bennie et al., 2018). Even if freshwater ecosystems are often exposed to ALAN from adjacent urban and sub-urban areas (Ceola et al., 2015; Secondi et al., 2017), the interest for ecological effects of nocturnal light in aquatic ecosystems is recent (e.g. Hölker et al., 2015; Grubisic et al., 2017). Plant consumption by aquatic herbivores induces important biomass losses and can participate to structuration of macrophyte communities (Elger et al., 2002). Herbivory rate is partly linked to plant palatability, which depends on mechanical and chemical characteristics of plants, which may themselves be affected by exposure to ALAN.

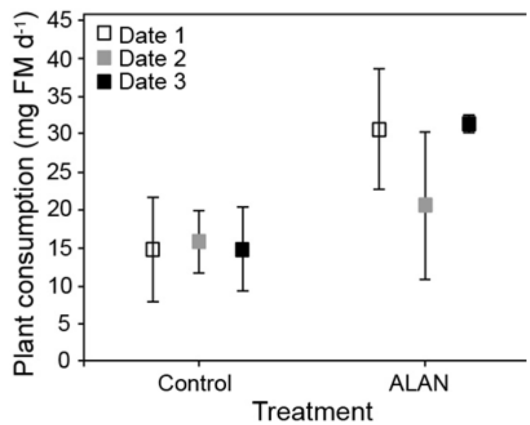

Fig. 1: Consumption rates of snails (mean ± sd) on control plant (Control) or on plants experiencing artificial light at night during three month (ALAN). The experiment was run at 3 dates.

In this study, we measured ALAN impact on 1) biomechanical characteristics of a freshwater aquatic plant, *Ceratophyllum demersum* L. (family Ceratophyllaceae), a hornwort, which is a submerged, floating rootless macrophyte and 2) herbivory by the snail *Lymnaea stagnalis*, a freshwater generalist feeder that consumes submerged plant tissue. We demonstrate that nocturnal artificial light at night increases the herbivory rate of aquatic plants: *C. demersum* leaves that have grown with artificial light at night were 1.5 time more consumed by aquatic mollusc than control leaves (fig.1). Because snails have not been exposed to ALAN and herbivory experiment occurred without artificial light at night, this increase is due to a modification of the palatability of the plant. However, our results showed that the increase of *C. demersum* palatability to the pond snail when plants were exposed to ALAN was not due to a decrease of dry matter content nor to a modification of the biomechanical characteristic of the leaves (leaf toughness was not modified by exposure to ALAN). As a consequence, this clear increase of herbivory rate observed in plant exposed to ALAN may be due to modifications of primary and /or secondary plant metabolisms.

Plants biodiversity is crucial for maintenance of ecological balance and stable food webs. Even if, habitat loss, climate change, pollution, invasive species, and overexploitation negatively affect almost all ecosystems, ALAN is emerging as another potential threat to biodiversity (Davies & Smyth, 2017). The results of this study suggest that ALAN is expected to affect ecological processes in aquatic ecosystem such as relationships in trophic networks that largely remain to be investigated.

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Light pollution creates an ecological trap for moths and alters community composition

Theme: Biology & Ecology

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Introduction

Artificial lights at night (ALAN) can have consequential impacts on species and may be an important mechanism causing biodiversity declines (Owens et al., In Press). Many studies investigate how light pollution affects single species, but understanding declines in biodiversity requires a community perspective. Further, ecological studies of light pollution usually test it as a categorical variable (light or no light) or measure only illuminance (the brightness of a point source of light), but ignore luminance (how bright objects appear or how much light is reflected off an object, e.g. sky glow). However, many organisms and ecological interactions are not only affected by point sources of light (illuminance), but brightness on a landscape scale (luminance).

Fig. 1: Shannon Murphy collecting luminance and illuminance data at one of our field sites (photo credit: Doug McCaskill)

One group of organisms that are well known for their response to artificial lights is moths, and ALAN has been suggested as a possible cause for declines in their diversity (Fox, 2013; Owens et al., In Press). Light pollution has negative impacts on moth individuals (Grenis & Murphy, 2019), populations (Firebaugh & Haynes, 2019), and has been shown to lead to evolutionary change (Altermatt & Ebert, 2015). However, whether these individual and population-level effects cascade to affect the structure of an entire community of species is unknown.

We empirically tested the hypothesis that ALAN can cause shifts in community composition of light-sensitive and light-insensitive species, focusing on communities of moths. We measured light as continuous measures of both luminance and illuminance, which allows us to explore the differential effects of types of ALAN on the diversity and community structure. Ours is the first ecological study to both test the effects of light pollution on an entire taxonomic community and also to use two quantitative measures of light pollution (illuminance and luminance) to test their separate effects on light-sensitive as well as light-insensitive species.

Methods

We surveyed moth communities at 23 prairie fragments along the Front Range of Colorado, USA, and collected data on illuminance and luminance at each site. Moth community responses to light will occur at large spatial scales, and thus we also tested other landscape factors that could drive moth community responses, such as vegetation diversity and habitat size. To evaluate differences in species richness and abundance, we used two multiple regressions with site area, vegetation diversity, illuminance, and luminance as independent variables. We analyzed moth community composition data using Nonmetric Multidimensional Scaling (NMDS) to create a dissimilarity matrix among the sites with the Bray-Curtis dissimilarity coefficient. We then tested for differences in community composition due to variation in illuminance and luminance among light-sensitive and light-insensitive species using ANOSIM.

Conclusions

We found that different measures of ALAN (luminance vs. illuminance) have different effects on communities. We found that sites with increased luminance (sky glow) have decreased moth abundance and species richness whereas sites with increased illuminance (streetlights) have significantly increased moth abundance and species richness, suggesting that streetlights act as an ecological trap for moths. We also found a shift in community composition between light sensitive and insensitive species, and this shift in community composition was related to a change in luminance. Notably, we found no relationships between moth abundance or species richness with habitat area or vegetation diversity. Our research shows empirically that light pollution has significant effects on moth communities and that point sources of light (streetlights) have contrasting effects on insects compared to brightness on a landscape (sky glow).

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Rethink the Night - A hands-on approach to applying lighting ethics, cultural semantics and cognitive wellbeing towards a night-friendly lighting design

Theme: Lighting Design

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Introduction

The "Rethink the Night" – Move suggests a process about acquainting aspiring lighting professionals with low level lighting design in outdoor spaces, by means of immersive educational experiences in the framework of a series of relevant workshops, commenced first in 2014

We review the first six editions with lighting designers as Alexandra Stratimirovic, Lara Elbaz, Iva Vassileva, Michael Day, Emrah Baki Ulas, Ruari O'Brian and others. We present various photometrical measurements at and above the installations, which prove the accordance of natural lighting with artificial, yet harmonious nightscape interventions.

We will focus on following three dominant lighting design aspects and their correlation with each other:

1) Human (and other species') health and as well as the intactness of the body and its undisrupted chronobiological performance must be respected and any risk-increase for diseases must be avoided with a consistent prevention approach; this leads to a requirement for mild lighting with an artificial lighting contribution, which has to be considered as a complementary counterpart of natural night lighting.

2) The semantics of Night as formed by diverse cultures in interaction with the experience of the local day-night rythm and its various manifestations has to serve as a valuable potential for night-minded conceptual lighting design in compliance with whole-body human vision, beyond visual pragmatics.

3) A circadian supportive light-and colour Syntactics, yielding advanced cognitive well-being beyond the functional aspects of an unscathed human physical condition

Fig. 1: Rehtink the Night – example of techniques : Chapel of the Archangel Michael with candle-flame graduation and linear applications of phosphorescence to the paving serve as "guide-lights". CC-BY

Night shift work and benign breast disease (BBD) risk in the Nurses' Health Study II

Theme: Health

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Introduction

Benign breast disease (BBD), particularly proliferative BBD, is a strong risk factor for breast cancer. Rotating night shift work has been previously associated with an increased risk of invasive breast cancer yet the relationship between night shift work and BBD has not been evaluated. We aim to investigate whether rotating night shift work history is associated with an increased risk of BBD in the Nurses' Health Study II (NHS II).

Methods

We prospectively assessed the risk of biopsy confirmed BBD (non-proliferative, proliferative with and without atypia) in relation to duration (years) of rotating night shift-work (≥3 nights/month) at baseline (1991), duration of cumulative night shift work in each follow-up cycle (updated in 1993, 1997, 2001, 2005, 2007), and recent shift work status in each follow-up cycle. We excluded participants who reported a prior diagnosis of cancer (except for non-melanoma skin cancer), previous self-reported or histologically confirmed diagnosis of BBD, and whose biopsy date was before the return date of the baseline shift work history questionnaire.

Results

Over 12 years of follow-up (1991 through 2013), 1,263 incidental cases of biopsy confirmed proliferative BBD (among 2,208 women who had valid information on biopsy-confirmed BBD) were identified among 66,475 women in the NHS II cohort. We observed no increased risk of biopsy confirmed proliferative BBD in relation to duration of shift work history (1-4.9 years: HR 1.04, 95% CI 0.92-1.17; 4-9.9 years: HR 1.00, 95% CI 0.82-1.20; ≥10 years: HR 0.77, 95% CI 0.56-1.05; Ptrend=0.29), duration of cumulative shift work (1-4.9 years: HR 1.05, 95% CI 0.92-1.19; 4-9.9 years: HR 0.99, 95% CI 0.82-1.19; ≥10 years: HR 0.86, 95% CI 0.66-1.12; Ptrend=0.35), or recent shift work in the past two years (1-9 months: HR 0.98, 95% CI 0.78-1.20; 10-19 months: HR 1.87, 95% CI 0.63-1.21; ≥20 months: HR 1.05, 95% CI 0.84-1.32; Ptrend=0.98). These null findings retained in stratified analyses by mammography status. No significant association was found between cumulative shift work duration with risks of developing proliferative BBD with or without atypia, nor non-proliferative BBD.

Conclusions

We found no overall evidence of increased risk of BBD in relation to rotating night shift work in the NHS II cohort. Future study should investigate other pathways though which circadian rhythm disruption may operate in breast cancer development.

Mediterranean islands under the impact of artificial light at night

Theme: Biology & Ecology

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The Mediterranean is considered as a World Biodiversity Hotspot because of a significant reservoir of endemics and their threatened with destruction (Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2000). Island ecosystems have the special importance for biodiversity conservation in this region. However most of them are under strong athropogenic influence: recreational load, infrastructure development, fires etc. At the same time new types of athropogenic pressure have arisen, one of which is artificial light at night (ALAN) and sky glow (Longcore & Rich, 2004). This factor has not been accepted as dengerous for people and biodiversity for a long time, but the last researches show absolute another state of affiars: it has significant influence on reproduction, navigation, behavior, foraging, habitat selection, communication, and social interactions of all living organisms(Falchi, 2018; Schroer & Hölker, 2017). Therefore, we have estimated the level of light pollution on the biggest fifteen islands of the Mediterranean (Sicily (Italy), Sardinia (Italy), Cyprus (the Republic of Cyprus), Corsica (France), Crete (Greece), Euboea (Greece), Majorca (Spain), Lesbos (Greece), Rhodes (Greece), Chios (Greece), Kefalonia (Greece), Menorca (Spain), Corfu (Greece), Ibiza (Spain), Djerba (Tunisia)) using available tools from Google Earth Pro, and the New World Atlas of Artificial Sky Brightness in the form of a kmz layer created by Falchi et al. (2016). As well islands or their terrirories without ecological light pollution have been allocated. The obtained results argue that light pollution is very high on these biggest islands; there is not any area with the "pristine" sky in terms used by Falchi et al. (Falchi et al., 2016). But there are 49 small islands or their parts with the "pristine" sky, total area is about 126.5 km2. As well 1,167,566.7 km2 or 46,61% of the Mediterranean Sea leave without ecological light pollution. More results and their discussion will be presented during the conference.

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Urban Lighting Research – Proposed Collaboration Process with Lighting Professionals

Theme: Technology and Design

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Over the past decades, the night-time environment of cities and towns have gradually sheltered an unnatural brightness and colour appearance with the use of artificial lighting technologies. Globally, many cities and towns has strongly relied on illuminated skylines and landscapes for a sense of safety and security, to commercialize a 24/7 lifestyle, to enhance the historical and architectural significance of a territory, and as a constant reminder to ponder our identity and culture. Artificial lighting technologies have been extensively exploited to provide vehicular and pedestrian visibility at night. Eventually, the use of lighting technologies prioritized the visual enjoyment of visitors after dusk over naturally dark-sky nightscapes. As a consequence, light pollution has adversely affected the night-time environment as a crucial component of ecosystems and biological processes necessary for the survival of all living organisms. However, how can the existing research on light pollution and ecological light pollution, which presents significant disturbances to physiological and behavioural responses across living organisms triggered by high levels of brightness, continuous light exposure and unnatural colour spectra at night, become tangible parameters to the practice of urban lighting? The aim of this presentation is to raise a call for knowledge collaboration from different experts related to the field of research in light pollution and the practice of lighting design. To facilitate the knowledge transfer of the above, it is required to identify properties of artificial lighting used for urban settings and how these may negatively impact the natural night-time conditions for urban ecology and biodiversity. To achieve sustainable lighting solutions, a close collaboration between Environmental Experts and Lighting Professionals is necessary.

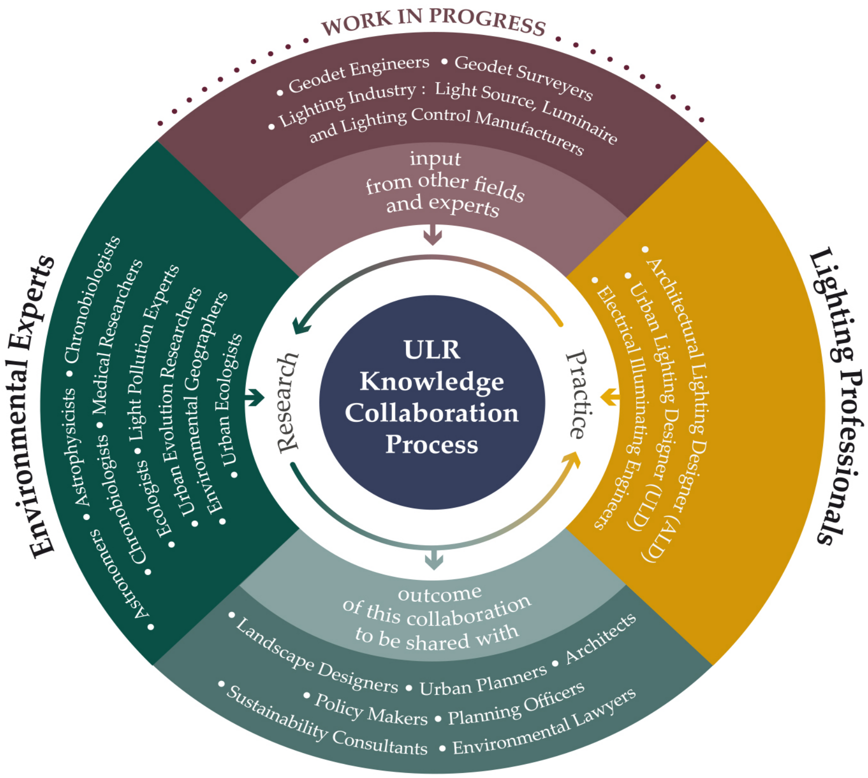

Fig. 1: Urban Lighting Collaboration Process. Source: Author's Elaboration

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Artificial light at night and (in)justice(s): A research agenda?

Theme: Society

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Concern about the multifaceted effects of artificial light at night (ALAN) is growing (for a recent overview of literature, see Davies and Smyth, 2018), but it remains an emergent issue in most scientific, policy, and activist communities. The problem of light pollution has also been framed in different ways over time (on the French case, see Challéat, Lapostolle, and Bénos, 2015). Many of ALAN's effects are, however, unevenly distributed. These inequalities raise vital questions about power and justice—pressing issues in many arenas in the early twenty-first century.

To date, some ALAN scholarship across a range of fields addresses justice—from public health (for an accessible overview, see Bogard, 2013) to philosophy (Stone, 2018). However, this theme has not been developed in a sustained fashion. Meanwhile, several programmatic articles have recently been published on ALAN research (Davies and Smyth, 2018; Pritchard, in prep) and night more broadly (Shaw, 2018; Gaston, 2019; Kyba et al., 2020), which have put forward visions of what research and scholarship might look like in the future.

In this paper, I argue that justice is a framework that should shape disciplinary and inter/ multi/transdisciplinary ALAN studies (Hölker et al., 2010), including in fields where it may seem unrelated. I then briefly discuss traditional environmentalism, some of the main criticisms (Cronon, 1995; Dowie, 2009), and the development of environmental justice (Delegates, 1991; Bullard, 1993). I suggest how ideas from both mainstream environmentalism and environmental justice are present in the ways that some ALAN scholars and activists frame ALAN as a problem, albeit in distinct ways. I then outline a *preliminary* taxonomy (selected examples below) to suggest just some of the ways in which justice could be incorporated more fully into future ALAN research.

In the *physical and biological sciences*, scholars could address: demographic identities of both professional and citizen scientists; research questions posed and sites studied; conduct of ALAN field research (Clancy et al., 2014); and analysis of ALAN imagery through a justice lens (Pritchard, 2017).

In *health* research, scholars could consider: differential health risks (race, class, immigrant and citizenship status, etc.) in populations with higher rates of shift/night work (Schernhammer et al. 2006); and differential health effects of living in urban environments, especially areas with higher rates of surveillance and policing (Browne, 2015; Henery, 2019).

In the *social sciences*, researchers could investigate: language, terminology, and history as "dark/ness" is implicated in racism and colonialism (Stanley, 1878; Conrad, 2018 [1899]); lighting as reflection of anxieties about race, class, gender, and sexuality; differential lighting in certain neighborhoods, public housing, and prisons (Incarcerated Workers, 2019) as technologies of surveillance; although the assumption that more lighting increases safety has been debunked by ALAN scholars, safety remains a legitimate concern for social groups disproportionately affected by violence (women, POC, LGBTQ+, etc.); and access to safe, clean, reliable ALAN in the developing world and underclass of "developed" world, who may have their electricity turned off.

In *activism*, organizers could consider: reforming lighting in urban, suburban, exurban, and/or industrial areas to prioritize human health, as well as urban wildlife and ecosystems; analysis of activist arguments supporting the protection of "dark skies" through the "nocturnal sublime" (Stone, 2018); and analysis of dark-sky preservation efforts, especially in the developing world, given the global history of conservation (Dowie, 2009).

The goal of this paper—and related submissions on ALAN and (in)justice(s)—is to foster greater conversation within the ALAN community across fields, with regard to how justice could be incorporated into disciplinary and interdisciplinary research, as well as inform policy and activism.

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A Multinational Study of Night Sky Brightness patterns: preliminary results from the Globe at Night – Sky Brightness Monitoring Network (GaN-MN)

Theme: Measurement & Modeling

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The Global at Night - Sky Brightness Monitoring Network (GaN-MN) is a multinational project for long-term monitoring of night sky conditions around the world. Established in January 2015, the GaN-MN consists of fixed monitoring stations each equipped with a Sky Quality Meter - Lensed Ethernet (SQM-LE), a specialized light sensor for night sky brightness (NSB) measurements. NSB data are continuously collected at high sampling frequency throughout the night, and are instantly disseminated publicly to provide a real-time snapshot of the global light pollution conditions. A unified data collection methodology, including data sampling frequency, data selection criteria, device design and calibration, and schemes for data quality control, was adopted to ensure uniformity in the data collected. The network has currently 49 stations operating in 14 countries/regions in Asia, Europe, Africa, and South America. Over 77 million individual NSB data entries had been collected up to December 2019. This huge NSB database allows for studies of temporal and geographical variations of light pollution and their correlations with various natural and artificial factors.

Preliminary analysis of this multinational data set reveals the huge variation in the night sky worldwide: urban night skies are significantly brighter than night skies in pristine national parks. In general, urban night skies get progressively darker with time over the night due to reduction in light usage. Distinct patterns of temperal variations of the NSB observed in different locations reflect the diverse policy and habit of lighting usage in the locations sampled. This data collected is intended to provide the scientific backbone in our efforts to contribute to dark sky conservation through education to the general public and policy makers.

Project website: http://globeatnight-network.org/. Archived data from the project also available at the Globe at Night website: https://www.globeatnight.org/gan-mn.php

This project is supported by the University of Hong Kong Knowledge Exchange Fund granted by the University Grants Committee, the Environment and Conservation Fund of The Government of the Hong Kong Special Administrative Region, and the IAU Office for Astronomy Outreach (OAO), IAU/NAOJ, Tokyo, Japan.

Impact of Light Pollution on the Circalunar Rhythm - an FFT Perspective

Theme: Measurement & Modeling

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Circa-monthly activity conducted by moonlight is observed in many species on Earth. Given the vast amount of artificial light at night (ALAN) that pollutes large areas around the globe, the synchronization to the circalunar cycle is often strongly perturbed. Using two-year data from a network of 23 photometers (Sky Quality Meters; SQM) in Austria (Posch et al. 2018), we quantify how light pollution impacts the recognition of the circalunar periodicity (Puschnig et al. 2019). We do so via frequency analysis of nightly mean sky brightnesses using Fast Fourier Transforms. A tight linear relation between the mean zenithal night sky brightness (<NSB>) given in $\mathrm{mag_{SQM}\ arcsec^{-2}}$ and the amplitude of the circalunar signal is found (see Figure 1), indicating that for sites with a mean zenithal NSB brighter than 16.5 $\mathrm{mag_{SQM}}$ $\mathrm{arcsec^{-2}}$ the lunar rhythm practically vanishes. This finding implies that the circalunar rhythm is still detectable (within the broad bandpass of the SQM) at most places around the globe, but its amplitude against the light polluted sky is strongly reduced. We find that the circalunar contrast in zenith is reduced compared to ALAN-free sites by factors of 1/9 in the state capital of Linz (~200,000 inhabitants) and 1/3 in small towns, e.g. Freistadt and Mattighofen, with less than 10,000 inhabitants. Only two of our sites, both situated in national parks (Bodinggraben and Zöblboden), show natural circalunar amplitudes. At our urban sites we further detect a strong seasonal signal that is linked to the amplification of anthropogenic skyglow during the winter months due to climatological conditions.

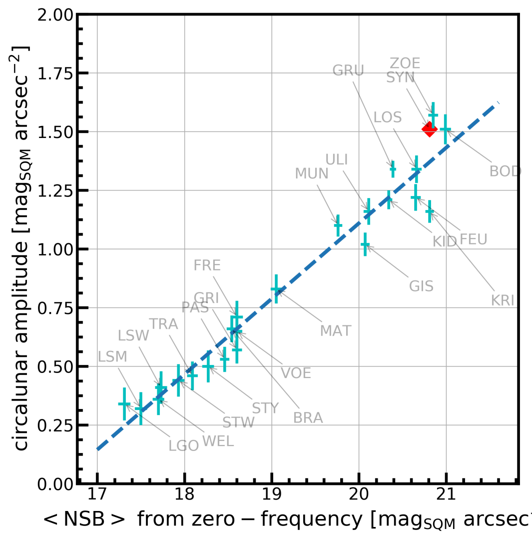

Fig. 1: Relation between the circalunar amplitude and zenithal mean night sky brightness (<NSB>) for mid latitudes (~48°). Individual points denote amplitudes derived through FFT analysis, with ±1σ errors found from the noise in the FFT amplitude spectra. The data is in good agreement with a linear relation with a scatter of only 0.06 $\mathrm{mag_{SQM}\ arcsec^{-2}}$. The red point denotes the amplitude and <NSB> for a synthetic sky model.

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Light over Vienna - a synoptic approach

Theme: Society

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Introduction

Fig. 1: Central Vienna during the all-direction light measurement campaign. The bright spot near the centre is due to one of the lights of St. Stephens cathedral. CC-BY.

To measure the light-immission and -energy-output of the city of Vienna and to document its change in concurrence with the installation of 150 000 new fully shielded, custom developed street-luminares, we developed a new synoptic city-monitoring concept and report results after 50 000 lights have been changed.

Methods

1) We measure the background (natural light at night) at our station (elevation 1500m) in the "Dürrenstein Wilderness", 111 km to the WSW of Vienna with a cadence of 1Hz.

2) We monitor the city light dome with a network of 8 lightmeters with distances from 0.5 to 111 km from the city center.

3) With a direction- and area complete measurement of the city lights based on two aerial campaigns we quantify the fraction of direct emission into the sky and measure the direction dependent radiance of all upward light sources in Vienna down to natural ground luminance levels.

4) The light-measurements obtained with the Kuffner-Observatory's Vienna lightmeter-network are combined with the air-quality monitoring network of the City of Vienna environmental department (MA 22). We construct correlations of the monthly medians of light and air-quality measures, including absolute and relative humidity as well as the pm2,5 and pm10 particle quantifiers

Conclusions

- The monthly median for clear moonless nights at the Dürrenstein-site, varies between 0.63 and 1.39 mlx (6.4 to 14 µW/m²) from 2011 to 2018 for horizontal illuminance and total radiation respectively. We coherently detect the daily and seasonal variations a described by zodiacal- and Milky Way-light-models and discuss a component analysis approach.
- The light-dome monitoring shows an increase of the annual energy output of the city until 2014/2015 with a slow-down and possible saturation effect in 2017/2018. Typical meen annual growth rates are 6% per year with substantial annual variation from 2011 to 2018. Results for 2019 will be reported during the talk.
- We will present and quantify the top 10 single upward light sources at the many Mcd level at the meeting. We also present the first "in-situ" measured angular distribution of the light emission of a city as obtained from in-flight Lightmeter measurements.
- We present the correlations between light-data (clear and all-weather) and air-quality indicators for 2016-2019 and conclude that monitoring with simultaneous air-quality-measurement is necessary for a clear separation of light and clear-atmosphere conditions. We propose a concept to reduce light-pollution measurements to a "clear air standard".

- We present a light environmental impact indicator for Mcd light installations and invite light-designers to propose there installations for a pilot assessment.

The impact of various spectral parameters of artificial outdoor light at night on breast cancer risk in Vancouver, British Columbia

Theme: Health

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Introduction
Experimental and epidemiologic studies suggest that light at night (LAN) exposure disrupts circadian rhythm, and this disruption may increase breast cancer risk. In a case-control study in Vancouver, BC, Canada, we investigated how different spectral parameters of outdoor LAN, as measured by the International Space Station, are associated with breast cancer risk, particularly in terms of light in the blue part of the spectrum.

Methods
A population-based case–control study was conducted in Vancouver, BC, Canada with incident breast cancer cases and controls frequency matched by age. Participants completed a questionnaire assessing personal, health, and lifestyle characteristics. This analysis was restricted to 687 cases and 719 controls who provided lifetime residential histories. Using time-weighted average duration at each home 5–20 years prior to study entry, six measures of cumulative average outdoor LAN exposure were estimated using International Space Station (ISS) data: luminance, wavelength-based lamp melatonin suppression estimates using blue-green or green-red colour band ratios, wavelength-and-intensity based melatonin suppression estimates using blue-green or green-red colour band ratios, and melatonin suppression estimates based on the light source technology that best matches the color band ratios. Outdoor LAN measures were categorized into tertiles, and logistic regression was used to estimate the associations between outdoor LAN and breast cancer risk and potential interactions for menopausal status and night shift work.

Results
Cases and controls were similar in age (57-58 years), and the majority were postmenopausal. Both cases and controls were predominantly of Caucasian ethnicity, with about one-quarter of the sample of Asian ethnicity. Cases were more likely to have a family history of breast cancer, and did not differ from controls in body mass index, never vs. ever shift work status, or other breast cancer risk factors. Most participants lived at one or two residences during the 5–20 year time period of interest prior to study enrolment (median of two residences, maximum of eight residences). The median duration spent at each residence was five years, with a median of 13 years of total residential history available within this window. Preliminary results do not suggest an association between the various spectral LAN measures and breast cancer risk, and there is no clear interaction by menopausal status or past/current night work status. Results will also be presented for exposure to light in various ranges of circumference around residences, and the impact of residential mobility and other exposure windows.

Conclusion

This study examines LAN exposure for women living at a considerably higher latitude than previous studies. Although other studies suggest a relationship between outdoor LAN (particularly in the blue spectrum) and breast cancer, our preliminary findings are consistent with no relationship between spectra and intensity of outdoor LAN measured using ISS photographs of Vancouver. Strengths of the study include the use of images with higher resolution around residences compared to some previous studies, and analysis of outdoor LAN using various biologically relevant parameters. Limitations of our study include that no information was collected on factors such as bedroom location within the home, curtain type, and use of sleep masks, and no information on melatonin supplementation was available. This makes it unclear how any LAN protection behaviors may have influenced our findings. More work is needed to understand the specific mechanisms linking outdoor LAN to breast cancer risk, particularly in terms of blue light exposure.

Night Sky Brightness and Color Changes in Madrid Skies During the Street Lighting Retrofit.

Theme: Measurement and Modeling

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We report on the evolution of light pollution in Madrid using the night sky brightness (NSB) monitoring devices at the UCM astronomical observatory in Madrid. The street lighting of Madrid and surrounding urban areas are changing from primarily High-Pressure Sodium lamps (HPS) to Light-Emitting Diode (LED) technology, mainly 3000K. The data collected showed that NSB and color of the skies varied as a direct result of this upgrade.

The filtered data showed changes from reddish to bluish skies with a distinctive transition during the year 2015, where a significant change took place. We are applying nonparametric statistics to investigate night sky brightness and sky color evolution with comprehensive datasets. We anticipate that the tools developed during this study may explain the possible trends of the temporal time series and its associated variability in other polluted skies with available monitoring data.

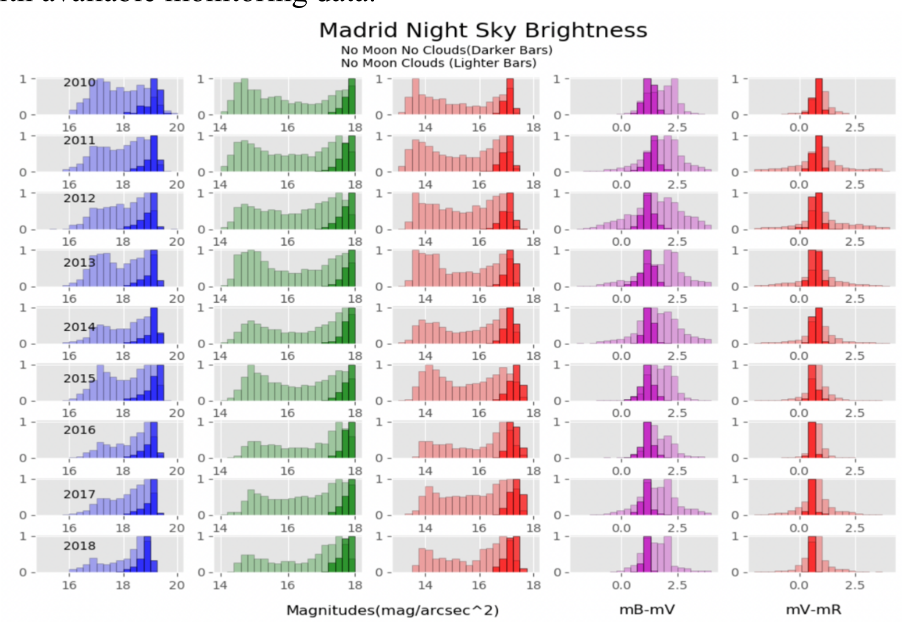

Fig. 1: Night Sky Brightness and Color Statistics from 2010 to 2018. From left to right, Johnson B, V, R magnitudes and B-V, and V-R colors. We present the histograms with darker bars for filtered data (no clouds and no moon over the horizon), and lighter bars for unfiltered data (with moon and clouds).

Light at night in Delayed Sleep Phase Disorder: a comparison with insomnia and healthy sleep

Theme: Health

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Introduction

The circadian system (CS) is responsible for the generation of biological rhythms, such as sleep-wake, synchronized with our environmental 24-hour light/dark cycle. Since light is its main synchronizer signal *(zeitgeber)*, aberrant light at night leads to circadian and sleep alterations[1,2].
The *delayed sleep phase syndrome (DSPD)* is a circadian disorder characterized by a delayed endogenous sleep-wake rhythm with respect to the desired/standard bed and wake-up times, resulting in chronic difficulty to fall asleep at night and to wake up early in the morning.
The aim of this study was to explore the circadian patterns of light exposure in a group of DSPD patients in comparison with insomnia patients and healthy subjects.

Methods

The study included 57 DSPD and 57 Insomnia (I) patients (according to the DSM-V criteria) so as 19 control subjects (C), all attending the Estivill Sleep Clinic (Barcelona, Spain). Their circadian rhythms of wrist temperature (T), motor activity (A), body position (P) and light exposure (L) were assessed during a week under normal-living conditions through the multichannel device Kronowise™ (Chronolab, Univ. of Murcia). Sleep-wake states were inferred using the integrated variable TAP (from T, A and P)[3]. The average of A during the five consecutive hours with lowest values (A-L5) and mean T during the five consecutive hours with maximum values (T-M5) were used as indexes of sleep quality. Accurate circadian phase estimation was determined using the L5/M5 timing of every rhythm[2,4-6]. Additionally, the M10 timing of L (ten consecutive hours of maximum values) was used to further explore potential delays in the light exposure cycle. The mean amount of light received during sleep (L-L5) was also assessed. These parameters were compared between groups through one-way ANOVAs.

Results

C showed higher T-M5 and lower A-L5 values, indicating better sleep quality, than both DSPD and I ($p < .05$), which did not significantly differ between each other ($p \geq .05$). DSPD showed significantly later T-M5 and A-L5 ($p < .01$) with respect to both I and C, confirming their sleep phase delay. Most relevant to our study, significantly higher L-L5 values and delayed L-M10 and L-L5 timings in DSPD ($p < 0.01$) indicated the presence of light at night.

Conclusions

Our results clearly show the relationship of light at night with delayed sleep. Although these data do not allow to determine causality, it is clear that the presence of light at night contributes to maintaining the sleep and circadian alteration in DSPD[1].

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The effects of low-intensity light on the 24-hour profile of lipid metabolism in rats

Theme: Biology & Ecology

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Introduction

Artificial light at night (ALAN) represents a relatively new form of circadian disruption and has been increasing dramatically during the last decades. The association between circadian disruption and metabolic diseases, such as obesity and type 2 diabetes, is suggested by experimental and epidemiological studies, but underlying processes are still not understood. In our previous study, we have found significant changes in the hepatic lipid metabolism as the consequence of ALAN exposure (Rumanova et al., 2019), which may increase the risk of metabolic diseases. To understand better the underlying mechanism, the aim of the present study was to analyze changes of 24-hour rhythms of selected metabolites and the gene expression of metabolic sensors involved in the control of lipid metabolism under ALAN conditions. Due to previously observed elevated hepatic lipid accumulation, one of the analyzed metabolic sensors was sirtuin 1 (SIRT1) because its deletion plays a major role in the development of hepatic steatosis. This enzyme couples the energy metabolism to transcription via the activation of other transcription factors, such as peroxisome proliferator-activated receptor α (Ding et al., 2017). We also studied liver X receptor α (LXRα) which is activated by the oxidized forms of cholesterol and as a transcriptional factor increases the expression of genes encoding enzymes responsible for bile acid synthesis (Baranowski, 2008). Moreover, we focused on differences in the rhythmicity of clock gene expression to reveal whether metabolic alterations are associated with circadian clock disruption.

Methods

Adult male Wistar rats were kept either at standard lighting regimen (CTRL, 12L:12D) or exposed to warm dim light (3000 Kelvin) at night during the whole dark phase (ALAN, 12L:12DL, 1-2 lx) for 2 weeks. Samples were collected every 4 hours throughout the 24-h period, with sampling starting at ZT06 (middle of the light phase). Plasma triacylglycerols and cholesterol were measured by enzymatic colorimetric kits. The hepatic expression of clock genes (*bmal1, clock, per2, reverbα)* and genes encoding metabolic sensors (*sirt1, lxrα*) were assessed by real-time PCR.

Results

The expected rhythmicity of plasma triacylglycerols and cholesterol levels was observed in the control group meanwhile ALAN exposure abolished these rhythms. Cholesterol levels were significantly elevated in the ALAN as compared to the control group. The expression of clock genes retained circadian rhythmicity after ALAN exposure and their acrophases were slightly advanced in comparison with controls. The hepatic expression of both *sirt1* and *lxrα* was rhythmic in the control group and ALAN eliminated their circadian rhythmicity.

Conclusions

Based on obtained and published results we elaborate on a model, in which the metabolic sensors, such as SIRT1, can inhibit the negative feedback loop of peripheral clocks and, together with LXRα, boost the β-oxidation of fatty acids, which is beneficial. We hypothesize that disruption of these metabolic regulators by ALAN can result in the elevated accumulation of hepatic lipids, which represents a risk factor for health. Since LXRα also stimulates cholesterol catabolism, the elevated cholesterol concentration may result from suppressed LXRα rhythmicity. Elevated cholesterol levels may represent another risk factor of ALAN for the development of metabolic and cardiovascular diseases.

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The nature of the diffuse light near cities detected in nighttime satellite imagery

Theme: Measurement & Modeling

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Introduction

The presence of diffuse light surrounding bright sources like cities has been an issue for nighttime images since the time of the DMSP. In the past it was unclear if the nature of this glow was an instrumental problem or a detection of real light. Using the VIIRS, photographs from the International Space Station (ISS), and the UCM sky brightness survey, we find an excellent correlation between the diffuse glow and the sky brightness. This demonstrates that the diffuse light that we see around cities is the same light that causes artificial sky brightness, although the light that we see from space has been scattered upwards instead of downwards.

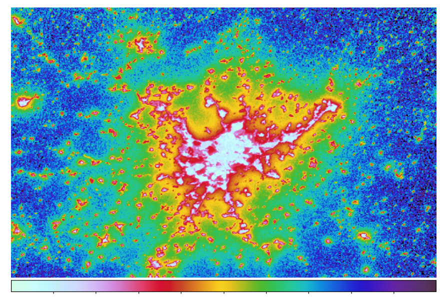

Fig. 1: Direct and indirect light observed from the Madrid area.

This fact means that it could be possible to produce sky brightness maps based on satellite measurements. Before this can be done, however, other factors must be considered, for example is whether the effect is related to changes of albedo of the ground, whether some real blooming occurs, as well as the possibility of scatter from low level water vapor (fog).

To validate these results, we compared the amount of skyglow predicted from Falchi et. al. (2016) to the satellite data in unlit areas. We also compared the satellite data to measurements taken on 6700 km of roadway around Madrid, based on a very dense campaign taken between 2010 and 2014. In conclusion, the satellite measurements are in very good agreement with the ground based sky brightness data data and the Falchi et. al. model. In fact, the data suggest potential improvements over the Falchi et. al. technique may be possible, as observations from space will not be succeptable to blocking by surface features (e.g. mountains). Further details about this analysis can be accessed on a recent preprint (Sánchez de Miguel et. al. 2019).

Methods

The space-based data sources are calibrated HDR images taken from the ISS, VIIRS images, and DMSP images. Ground based data are from the SQM survey described in Zamorano et. al. (2014), and the Falchi et. al. (2016) model is also used for comparison. Finally, MODIS data has been used for surface reflectance data. The data processing was done using Google Earth Engine and Python.

Conclusions

The diffuse light observed around cities is primarily caused by light emitted from cities that is scattered in the atmosphere. This diffuse light can be used as a proxy for sky brightness modeling. Ground albedo is detectable on the low light of highly sensitive data as the VIIRS data.

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Rotating nightshift work and hematopoietic cancer risk in U.S. women

Theme: Health

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Introduction

Nightshift work is a plausible risk factor for hematologic cancer, but epidemiological evidence remains sparse, especially for individual subtypes. We prospectively examined the association of rotating nightshift work with hematopoietic cancer risk.

Methods

This cohort study included US females from the Nurses' Health Study (NHS: n=76,846, 1988-2012) and Nurses' Health Study II (NHSII: n=113,087, 1989-2013). Rotating nightshift work duration was assessed at baseline (both cohorts) and cumulatively updated (NHSII). Cox regression was used to estimate hazard ratios (HRs) and 95% confidence intervals (95%CIs) for overall hematopoietic cancer and specific histologic subtypes.

Results

We documented 1,405 (NHS) and 505 (NHSII) incident hematopoietic cancer cases during follow-up. In NHS, compared to women who never worked rotating nightshifts, longer rotating nightshift work duration was associated with an increased risk of overall hematopoietic cancer ($HR_{1\text{-}14yrs}$=0.93, 95%CI, 0.83-1.04; $HR_{\geq 15yrs}$=1.28, 95%CI, 1.06-1.55; *P* for trend=.009). In NHSII, results were similar, though not statistically significant ($HR_{1\text{-}14yrs}$=0.99, 95%CI, 0.82-1.21; $HR_{\geq 15yrs}$=1.41, 95%CI, 0.88-2.26; *P* for trend=.47). In the subtype analyses in the NHS, the association of history of rotating nightshift work with risk of diffuse large B-cell lymphoma varied by duration ($HR_{1\text{-}14yrs}$=0.71, 95%CI, 0.51-0.98; $HR_{\geq 15yrs}$=1.69, 95%CI, 1.07-2.67; *P* for trend=.01), compared with those never having worked rotating nightshifts. Women reporting a longer history of rotating nightshifts also had suggestive (non-significant) increased risks of overall non-Hodgkin lymphoma ($HR_{\geq 15yrs}$=1.19, 95%CI, 0.95-1.49), Hodgkin lymphoma ($HR_{\geq 15yrs}$=1.32, 95%CI, 0.43-4.06), and multiple myeloma ($HR_{\geq 15yrs}$=1.42, 95%CI, 0.85-2.39).

Conclusions

Longer duration of rotating nightshift work was associated with increased risks of several types of hematopoietic cancer.

Working with inadequate tools: Legislative shortcomings in protection against adverse effects of artificial light

Theme: Society

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Background

The fundamental change in nocturnal landscapes due to the increasing use of artificial light at night (ALAN) has a detrimental impact on the environment. This raises important regulatory questions: Does the environmental law of the EU and the member states provide sufficient protection in ALAN-related conditions? Which organisms or landscapes potentially suffer from protection gaps? And, which measures could be implemented to reduce the negative impact of ALAN and to improve the protection status of landscapes and organisms during night time?

Methods, Results & Conclusions

The study uses an interdisciplinary approach. The legal framework highlighted outlines European and national law, using the German federal environmental law as an example, based on an analysis by Huggins & Schlacke (2019). The European legislation includes several legal acts that are related to ALAN, which are only in part directly applicable in all European member states but mostly binding as to the result to be achieved. The existing regulations were put in context to over 300 studies indicating significant disturbances of organisms and landscapes.

European and German environmental law include the protection for specific species, the protection of selected habitats (e.g., Natura 2000 network) and legislation on light emission control. However, these provisions are limited in (a) its spatial and (b) material scope of application as well as (c) its conditions of application. Protection is effective for protected species that demonstrate discernible avoidance behaviour when lit causing habitat loss, e.g. bats . However, adverse effects on species and landscapes without discernible bevaviour change or without special protection status are either unaddressed by the law or ineffectively regulated. We indentified three sets of reasons why the application of the law is lacking and legislative shortcomings persist. One is the lack of expertise and awareness, including knowledge gaps. Another is the deficit of the scope of protective legal regimes. The third is caused by deficits in applying adverse effects of ALAN to the law.

Relevant protective provisions, such as the prohibition to kill or disturb specimens, use a strict approach, i.e., prohibiting the death or disturbance of a protected specimen. When applicable they are effective to safeguard the conservation status of rare and endangered species. However, the list of species as provided in Annex IV of the Habitats Directive is rather short and does not address explicitly light-sensitive organisms (EU Commission, 2007). ALAN affects a wide range of taxa, ecosystem services and nightscapes regardless of the protection status or natural habitat type. It inflicts stressors on the ecosystems and food webs resulting in a deterioration of habitats and biodiversity by compromising the robustness against other stressors, which results in shortcomings in legal protection of biodiversity and landscapes by the law.

Presentation

The presentation of the study will consist of an interview. The natural scientist, Sibylle Schroer, will raise questions according to some selected studies indicating detrimental effects on various organisms, such as bats (Azam et al., 2018; Hale et al., 2015; Russo et al., 2017), migrating birds (Cabrera-Cruz et al., 2018), domestic birds (Ouyang et al., 2015), amphibia (van Grunsven et al., 2017) and insects (Donners et al., 2018). In addition, Schroer and Huggins discuss possible protection measures against adverse ALAN effects on protected landscapes (Garrett et al., 2019) and ecosystems in non-protected areas (Grubisic et al., 2017; Manfrin et al., 2017). The legal expert, Benedikt Huggins, will discuss these threats on the biodiversity and indicate existing protection measures or gaps according to the legal framework. The team will conclude in discussing possible measures to reduce ALAN-induced environmental impacts, whether an obligation to implement such measures is favourable for environmental protection and how regulations could be implemented in the future.

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The latitudinal photoperiod gradient and artificial light at night, a missing link

Theme: Biology and Ecology

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Artificial light at night (ALAN) has spread and keeps on expanding over all continents and most biomes (Falchi et al 2016, Kyba et al. 2017). Many biological and physiological effects have been reported on diverse organisms. Yet, little information is available outside the temperate zone, especially in the intertropical zone, despite the fact that it hosts the largest fraction of diversity on Earth. Consequently, we do not know whether the strength of the induced effects is the same across the globe. Studies have shown that many traits are affected by photoperiod (Hut et al 2013). We argue that the influence of latitude has been largely overlooked until now although this primary biogeographical factor determines the annual variation in day length and, therefore the annual regime of exposure to ALAN (but see Da Silva et al 2017, Bennie et al 2014).

We give examples of how biological traits that vary with latitude may be affected. We also highlight natural factors that vary across latitude and that can modulate the intensity of ALAN like moonlight and twilight (Secondi et al 2020). We particularly emphasize the role of cloud cover that strongly enhances night brightness (Kocifaj & Lamphar 2014). Using MODIS satellite images, we illustrate the fact that the frequency of overcast sky nights is higher across a large fraction of the intertropical zone and at high latitudes. ALAN-Induced effects may be stronger in these zones and occur at different times of the year. The intertropical zone is not currently the most exposed to ALAN. However, UN projections and academic studies predict a fast growth of human populations, urbanized areas and road networks in these regions, where cloud cover may be an aggravating factor. The consequences for biodiversity will primarily depend on the response of organisms to the shortening of the dark period.

Low plasticity to changes in the light regime is expected for organisms living at low latitudes, *i.e.* in stable photic environments, but this hypothesis has raised limited interest in light pollution studies so far. We initiated a research program on amphibians to investigate the variation in sensitivity to ALAN at different latitudes. We focus on Bufonidae, the anuran family the most broadly distributed in the world, and for which effects of ALAN have been detected (Touzot et al 2019). We present here the first results of an experiment carried out a in a broadly distributed tropical anuran species, the Cane toad *Rhinella marina*, in Costa Rica (7°N). Adults were exposed for 12 days to no light, 0.04 or 5 lux at night in outdoor mesocosms. Locomotor activity was reduced at light intensities as low as 0.04 lux, and the pattern shifted from crepuscular to nocturnal. Contrary to humans and mice, where ALAN is suspected to favour obesity, exposed toads did not gain weight whereas controls did. Corticosterone concentration also decreased as a possible consequence of the reduced activity or a time shift in the diel expression peak.

Our study highlight that ALAN can (i) generate strong behavioural and physiological disruption in intertropical species, and (ii) opposite physiological effects among vertebrate groups. Therefore, we strongly emphasize the urge to develop a biogeographical and ecological framework to study the effects of ALAN on biodiversity and to increase our efforts to study the impact of the changing nocturnal environment in the intertropical zone.

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Quantification of the light environment to assess its impact on the flight behavior of moths

Theme: Biology & Ecology

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Moths play an important role in terrestrial ecosystems [MacGregor et al. 2015] and are susceptible to artificial light at night (ALAN) [Degen et al. 2017, Knop et al. 2017]. Therefore, it is important to investigate the consequences of light pollution on their behavior. For example, among others, moths can orientate themselves at night by celestial bodies [Collett et al. 2016]. The most easily perceived celestial body during the night is the moon, which can be more difficult to use as a compass than the sun because of its variable, temporally limited visibility [Wehner 1984]. This way of orientation might get disturbed by ALAN since every street light is clearly brighter than the moon at a local scale.

To answer the question how flights of moths can get affected by ALAN, another important question needs to be addressed in advance: How can the light environment be quantified and described? To respond to this question a field experiment for seven weeks was conducted in a rural area in Hesse, Germany. Large moths were caught at a capture site and their flights were tracked by a harmonic radar. Six artificial light sources arranged in a circle around the release site were used to change the light environment individually.

All-sky imagery was used to quantify the light environment during each flight with one picture taken every minute [s. a. Jechow et al. 2019]. In the end, flight tracks and all-sky images were combined for each individual moth (Figure 1).

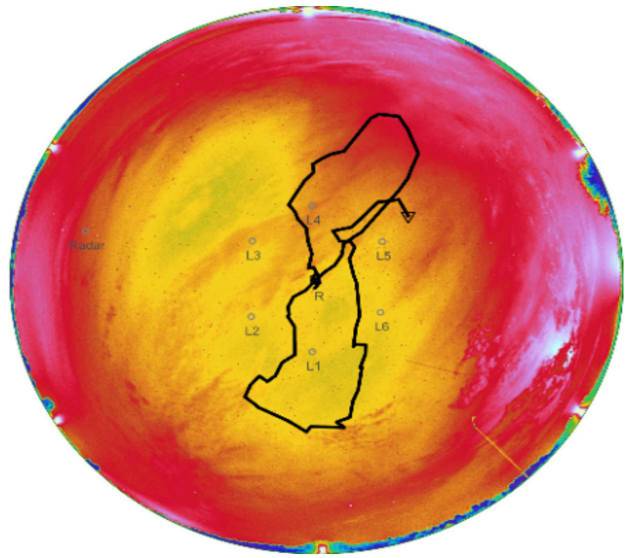

Figure 7: Compiled flight tracks and conjunction with all-sky imagery. L1 – L6 = lamp 1 – lamp 6, R = release site. A square marks the beginning of the flight, a triangle marks its end.

In a very local view even equal lamps showed differences in brightness from the perspective of the release site. The differences in the light environment depending on environmental circumstances like fog, clouds and sky signals were manifold. The area of the horizon could be subjected to much larger fluctuations due to the moon. *Euthrix potatoria* mainly flew in the direction of the brightest lamps but some moths showed an avoidance behavior. The results illustrate that a combination of recording flight trajectories of freely moving moths and analyzing the prevailing light environment in detail is a promising method to better understand the complex nature of night orientation in moths.

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Angular distribution of upwelling artificial light in Europe as observed by Suomi–NPP satellite

Theme: Measurement & Modeling

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Measurements of the directionality of artificial light are necessary for light pollution modeling. While not as refined as ground-based measurements using cameras and spectrometers, the recent availability of satellite-borne imaging sensors capable of measuring during the night time, enables us to measure the angular distribution of artificial light over a wide area. Examples are the VIIRS–DNB sensors onboard the Suomi NPP and the NOAA–20 satellites,

We downloaded night time images of Europe taken by the VIIRS–DNB sensor in 2018 onboard the Suomi NPP satellite and calculated a quadratic fit for measured radiance concerning the satellite zenith angle for each grid point. We found that the quadratic term of the fit, which can be used to characterize the intensity of artificial light emitted closer towards the horizon relative to that at the zenith, tends to be positive outside of the urban areas, and vice versa in the city centers. The slope term, used to determine the asymmetry of the emission, reveals that more light is observed at the direction which urban areas are underneath of the line of sight. We will discuss the variability of the data, as well as the potential influence of aerosols in the angular distribution of uplight. The data will be published to facilitate in-depth studies of specific areas.

Since the architecture of the VIIRS–DNB sensor onboard the NOAA–20 satellite (and the other upcoming JPSS series satellites) is similar to that on the Suomi NPP (except for the subpixel aggregation scheme at the scan edge applicable from NOAA–20 and onwards), this analysis technique can also be applied to all VIIRS–DNB images by the future missions, and will allow long-term observations and ecological impact assessments.

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Transcriptomic response of common toad, *Bufo bufo,* tadpoles to artificial light at night

Theme: Biology & Ecology

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Introduction

The alternation of daily cycles of darkness and light is one of the most important environmental cues that organisms use to regulate their internal clock and to synchronize their physiological and behavioural activities (Bradshaw & Holzapfel, 2010). Artificial Light At Night (ALAN) is an emerging pollution, that dramatically keeps on increasing worldwide (Kyba et al., 2017). To date, all terrestrial and aquatic ecosystems have been affected. Effectively, growing number of studies have begun to measure the influence of ALAN on the physiology and the behaviour of organisms. However, little is known about the effects of ALAN at the molecular level. The disruption of natural light cycles due to ALAN is particularly expected for nocturnal species, which require dark periods to forage, move, and reproduce (Buchanan, 2006). Amphibians, which contain the largest proportion of nocturnal species among vertebrates (apart from chiropterans), exhibit an unfavourable conservation status due to anthropogenic changes in natural ecosystems (Blaustein et al., 2014). Indeed, amphibians are frequently found in urban and peri-urban areas with wetlands which are subjected to ALAN (Secondi et al., 2017). In previous studies, we have shown that ALAN reduced nocturnal activity (Touzot et al., 2019) and affected breeding behaviour and fertilization success of adult toads (Touzot et al., 2020). It is therefore of particular interest to understand how ALAN may affect the circadian gene expression cycle, which could be one of the mechanisms contributing to the harmful effects of light pollution on the physiology and ecology of this species.

Methods

We first assembled a *de novo* transcriptome of common toad, *Bufo bufo* (38692 coding sequences). We then used Illumina RNA-seq to evaluate the transcriptome-wide gene expression response in common toad, experimentally exposed at night, since the day after laying, to ecologically relevant light intensities (0.01 (control), 0.1 (low) or 5 (high) lux). After 27 days of exposure, 5 biological replicates were collected at two times (13:00 and 01:00) for each light treatment.

Light treatment had a significant effect on gene expression as the expression of 1194 and 3676 genes differed when comparing 0.1 and 5 lux, respectively, with control. Regarding the circadian cycle, in the control group, the time of sampling significantly affected the expression of 1518 genes. Under light treatment, the time effect was lower, in particular at low light treatment (882 and 1274 genes differentially expressed in 0.1 and 5 lux, respectively). Thus, interaction between light treatment and time of sampling significantly affected gene expression, in particular at low light treatment. Indeed, only 1 gene displayed a significant interaction between light treatment and time of sampling at 5 lux, compared with 74 genes at 0.1 lux. Among these 74 genes, many are involved in immune responses, in stress and oxidative stress, in growth and in the regulation of gene expression.

Conclusion

Our study is the first to demonstrate the effects of ecologically relevant light intensities on gene expression in amphibians. Gene expression was affected at both, low and high light intensities, and more strongly at high intensity. Moreover, our data shows that the time effect differed when tadpoles were exposed to ALAN compared with controls, mainly at low intensity, suggesting a deregulation of the circadian gene expression cycle. Overall, the results suggest that a wide range of physiological pathways may be affected by ALAN at the molecular level.

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The impact of ALAN on moths, individuals and populations
Theme: Biology & Ecology

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That artificial light attracts moths is known for a very long time and concerns about the impact of ALAN on moths have been raised for quite some time. More recently, several other impacts of artificial light on individual moths have been described. Moths feed less, produce less pheromones and mate less frequent when illuminated (van Geffen et al. 2015a, van Geffen et al. 2015b, Van Langevelde et al. 2017). This might translate to reduced population sizes but not necessarily so. There are several studies that found indications that ALAN might be an important driver of the current declines in moth populations; e.g. in more illuminated areas in the UK the declines were more severe (Wilson et al. 2018). These studies are, however, correlative. ALAN often co-occurs with other anthropogenic disturbances making interpretation difficult. Moth species that are attracted to light sources were found to have declined more than species that are not attracted to light (van Langevelde et al. 2018) suggesting that light does indeed play a role.

To test the impact of ALAN on moth populations we set up an experiment where forest edges are illuminated with white, red or green streetlights with dark controls (Spoelstra et al. 2015). This setup is replicated on different locations in the Netherlands. Moth populations were monitored using Heath traps. As we expected that initial effects might differ from long term effects we analysed these separate. In the first two years the number of moths caught at the light treatments was not different from the dark control. In the second phase, third to fifth year, the number of moths caught in the light treatments was significantly reduced compared to the dark control indicating a negative effect of ALAN on moth populations (van Grunsven et al. in press). This shows that ALAN has a negative effect on moth populations in the long term and, given that it is widespread and increasing, plays a critical role in the current decline of moths.

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The GONet (Ground Observing Network) Camera: An Inexpensive Light Pollution Monitoring System

Theme: Measurement & Modeling

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Introduction

Instrumentation developed to monitor and characterize light pollution from the ground has helped frame our understanding of the impacts of artificial light at night (ALAN) (Bará et al., 2019; Hänel et al., 2018; Zamorano et al., 2017). All-sky imaging has been used to quantify and characterize ALAN in a variety of environments (Duriscoe, 2016; Jechow et al., 2019). Over the past decade growth in access to DIY electronics has afforded the opportunity for the development of new and affordable instrumentation for ALAN research.

The GONet (Ground Observing Network) camera is an inexpensive (~USD 100), simple to use, all-sky imaging system designed to allow measurements of sky quality at night. Due to their ease of use and low price, GONet cameras allow observations by users with little technical expertise, large inter-comparison campaigns and deployments of opportunity. Developed as a student engineering project at the Adler Planetarium, initial field tests of the GONet system have demonstrated its utility as a tool that can benefit ALAN research.

Here we present an overview of the design of the GONet device, methods of calibration, initial results from observations and potential use cases for the system.

Fig. 3 CAD rendering of version 2 GONet camera

Design and Data

The GONet system has a balance of benefits and limitations. The system is a small, self-contained board-camera imaging system with a GPS and simple user interface. Every five minutes it collects five images each a six-second exposure. The five 2π raw images are later stacked to effectively create a 30-second exposure. After an imaging run, users upload the images to a shared web server. Each image records the time and GPS location of the camera. Due to the goal of keeping the units affordable, exposure times are limited, resolution is low and system noise is high compared to more expensive all-sky systems. Compared to the capability of a device such as an SQM that offers a one-dimensional reading of zenith brightness, GONet cameras can be used to measure zenith brightness, generate full-sky luminance gradients and provide rudimentary color information via Bayer RGB data.

The initial model was calibrated with the help of Night Sky Metrics (D. Duriscoe and S. Balm) and tested in the field alongside the U.S. National Park Service all-sky imaging system. Recommendations from these and other tests have led to a version 2 GONet with increased stability, better imaging quality and expanded capabilities.

Results and Applications

To date, approximately 50 GONet units have been tested in field deployments. A group of teen program participants at the Adler Planetarium were trained in the use of GONets and have been instrumental in the field testing of the devices. These tests include coordinated deployments across the Chicago area comparing localized sky glow conditions, comparison of sky quality between Chicago and a nearby less light polluted national park (Indiana Dunes) and a joint deployment of 14 GONet cameras across 100km in support of an application by a local forest preserve for IDA Urban Night Sky Place designation.

These test deployments have helped to inform potential future applications of the GONet hardware for research. Some of these uses may include: Observing time-dependent ALAN features throughout a night or over long durations, distributed and coordinated observations to build radiative transfer models and the monitoring of sky glow color through lighting transitions.

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The Natural Night as a Habitat – the LAN-state of two Austrian Natural World Heritage sites

Theme: Biology & Ecology

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Introduction

The IAU-UNESCO initiative on Astronomy and World Heritage has made a decade long effort to protect the starlight-sites in the framework of the world heritage convention.

In Austria that resulted in the listing of the first World Natural Heritage sites, the Kalkalpen National Park, https://www.kalkalpen.at/, and the Dürrenstein Wildernis, http://Wildnisgebiet.at/. Efforts for a World Cultural Heritage site at the "Großmugl Starlight Oasis", http://starlightoasis.org are ongoing and focus on a "Hallstatt-period mines and tumui" concept, developed with the Department of Prehistory of the Vienna Natural History Museum.

In its first year the project, "Lebensraum Naturnacht" (The natural night as habitat) **obtained long-term monitoring for 4 sites and multi-directional light measurements for 30 habitats.**

Fig. 1: Legstein-Alm. Dürrenstein Wildernis; IUCN Ia (top) and Ebenforstalm, Kalkalpen National Park, IUCN II (Bottom). Two alpine habitats on the World Heritage List in direct comparison . Mostly LAN but ALAN contributions are visible towards the left in the Kalkalpen National Park. All rights remain with the Author

Methods

Methods include: 2010-2020 monitoring with an alpine lightmeter-network and identification of the most important sources contributing to the artificial brightening at a protected site by direction dependent measurements. The following results will be sketched: (1) the development of the monthly medians of nighttime total radiation over the Dürrenstein Wildernis from 2012 to May 2020, with a comparison to a natural light model that includes the contributions of the Sun, the Moon, the atmosphere, Zodiacal Light and the Milky Way and an estimate of the trends in artificial sky brightening; (2) a comparative investigation of the light-situation in three habitats, two lunar phases and three seasons.

Conclusions

The natural light levels and variations are detected in the Duerrenstein-Wildernis time-series, including the Milky Way and Zodiacal light modulations. Light levels in the Dürrenstein Wilderness cannot be distinguished from natural levels as measured at Atacama sites and possible trends can be limited to 10% per decade or less, with the limitations dominated by natural variations. By removing known correlations of light to humidity and particulate matter we demonstrate a significant improvement on the sensitivity of long-term trend versus clear weather-scatter. Light levels reach marginal pollution levels in some parts of the Kalkalpen World Heritage site with luminance/radiance significantly above natural in 10% of the directions.

Dim light at night disrupts circadian hormonal rhythms in rats

Theme: Health

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Introduction

Circadian rhythms are the essential part of the complex homeostatic regulation because they enable synchronization of rhythmic processes in living organisms with rhythmic environmental conditions. They are evident in most of physiological and behavioural variables and are governed by the central clock localized in the suprachiasmatic nuclei (SCN) of the hypothalamus in the coordination with the peripheral clocks in different organs. Circadian oscillations at the central and peripheral level are generated by the conserved transcription-translation feedback loop of core clock genes, which have similar features in the central and peripheral oscillators. The central clocks in the SCN communicate with peripheral organs mainly via the autonomic nervous system and endocrine system. Deregulation of circadian rhythms and a perturbation of such a delicate equilibrium may result in development of several pathologies, such as diabetes type 2, obesity and cancer. Several conditions can disrupt circadian organisation and artificial light at night (ALAN) is one of them, although data are still limited. In our previous studies we demonstrated that low intensity ALAN had negative effects on the circadian control of the cardiovascular system (Molcan et al., 2019) and these effects were even more pronounced in spontaneously hypertensive rats, in which ALAN exacerbated their insulin resistance and hypertension (Rumanova et al., 2019). These complex changes were accompanied with changes in expression of metabolic genes in the liver and partially also in the heart and adipose tissue. Surprisingly, little is known about consequences of a whole-night exposure to dim ALAN on circadian endocrine rhythms and underlying metabolic processes. Therefore, the aim of our experiments was to explore circadian rhythms of selected hormones together with rhythmic expression of clock genes in the liver in rats exposed to dim ALAN for the whole night.

Methods

Adult male rats were exposed for two weeks to either the standard light (L)/dark (D) regime (12:12 h) or dim (~ 2 lx) warm light (3 000 Kelvin) during the whole dark phase (ALAN group). Samples were taken in 4-hour intervals over a 24-hour cycle and plasma concentrations of melatonin, corticosterone, leptin, adiponectin, testosterone, thyroid-stimulating hormone and thyroid hormones (thyroxin and triiodothyronine) were measured by radioimmunoassay or enzyme-linked immunoassay. Melatonin was determined also in the pineal gland after solvent extraction. Clock gene (*Bmal1, Per2, Clock, Dbp* and *Reverbα*) expression in the liver was determined by real time PCR.

Results

Exposure to ALAN resulted in a loss of melatonin and testosterone rhythmicity in plasma while a low amplitude rhythm was preserved in the pineal gland. Another key circadian rhythm - plasma corticosterone was substantially supressed in the ALAN as compared to control rats indicating a weakened circadian control of peripheral organs in ALAN group. Plasma leptin concentrations were rhythmic in both control and ALAN groups and ALAN advanced amplitude of leptin and corticosterone rhythmicity by approximately 2 hours compared to controls. Concentrations of insulin and adiponectin levels exhibited high variability and did not show significant circadian oscillations. Plasma concentrations of TSH, thyroxin and triiodothyronine, that control energy metabolism, were arrhythmic and were not significantly affected by ALAN exposure. Expression of clock genes in the liver was rhythmic after ALAN exposure and acrophase of *Bmal1* was phase advanced. The pattern corresponds with the advanced rhythm of plasma leptin and corticosterone and resembles the pattern found in diabetes (Herichova et al., 2005).

Conclusion

The elimination of circadian rhythms in plasma melatonin and testosterone together with the altered leptin and corticosterone profile suggest that even low levels of ALAN can interfere with complex neuroendocrine regulation of physiological and behavioural processes and may represent a new type of endocrine disruptors. The complex circadian disruption of hormonal rhythms illustrates multiple mechanisms how ALAN participates in deregulation of behavioural and physiological processes and the subsequent development of multifactorial metabolic, psychiatric and metabolic diseases. Exact mechanisms how circadian disruption contribute to pathologies are not sufficiently known but are necessary for elimination or attenuation of negative effects of ALAN on health.

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Light Pollution in Environmental Planning (Landscape Planning, Environmental Assessment and Habitats Directive Assessment)

Theme: Society

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Awareness of the effects of artificial light on people and the environment has recently increased. Scientists and planners are looking for ways to avoid the negative environmental impact that can result from artificial lighting (as shown in Böttcher, 2001; Held et al., 2013; Krop-Benesch, 2019; Rich & Longcore, 2006 and many others). At the moment, Germany, like most other countries, has no applicable law regulating the use of artificial lighting in outdoor areas. The task of environmental planning is to protect nature and landscape, including biological diversity, the performance and functioning of the natural balance as well as the diversity, characteristic features and beauty of nature and landscape. Such protection includes management, development and restoration (BNatSchG, 2009).

The project "Light and Light Pollution in Landscape Planning" (Zschorn, 2018) examined the three instruments Landscape Planning, Habitats Directive Assessment (HDA) and Environmental Assessment (EA). 91 current examples of those instruments have been reviewed to find out which possibilities they offer to influence the use of artificial outdoor lighting and whether those approaches are utilized.

If properly implemented, all three instruments can be used to ensure environmental protection against impairments caused by light. The prevention-oriented and comprehensive approach of Landscape Planning can create protected areas and determine standards for environmentally optimized use of light. Moreover, it can be the basis for other planning processes and the use of subsidies. The EA has the advantage of being involved in such concrete planning processes, thus it can influence the handling of light in projects or plans within this process. With the help of the HDA it is even possible to prevent a plan or project if it is causing significant effects because of its light emissions.

Although it has been shown that all mentioned instruments are able to interfere regulatively, the implementations concerning outdoor lighting systems are in most cases currently incomplete. 89,4 % of all the examined examples showed gaps, especially in the analytical examination of existing or planned lighting installations and the possible adverse effects on nature and landscape. 61,7 % did not consider the topic "artificial light" at all (Zschorn, 2018). Therefore, the environmental planning cannot use their protective effect relating to light emissions.

It can be assumed that the insufficient consideration is due to a lack of knowledge among planners about how they can incorporate the issue. Further work in the project will be the development of a recommendation for future landscape planning processes, considering the deficits of the examined examples of landscape planning. A method will be developed which enables planners to analyse and assess the lighting situation of an area. The method will be developed for a sample area with the help of ArcGIS from ESRI and includes the three steps:

1. Description and analysis of the existing lighting situation (based on a lighting inventory)

2. Light-sensitive areas for animals, people and landscape

3. Conflict zones as an intersection of step one and two where different measures can be set

As a result, the developed recommendation should help planners to include the topic of light use and its regulation in environmental planning processes such as Landscape Planning, Environmental Assessment and Habitats Directive Assessment.

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