The ALAN challenge: measure, identify and mitigate

Comparative approach on new technologies

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Introduction

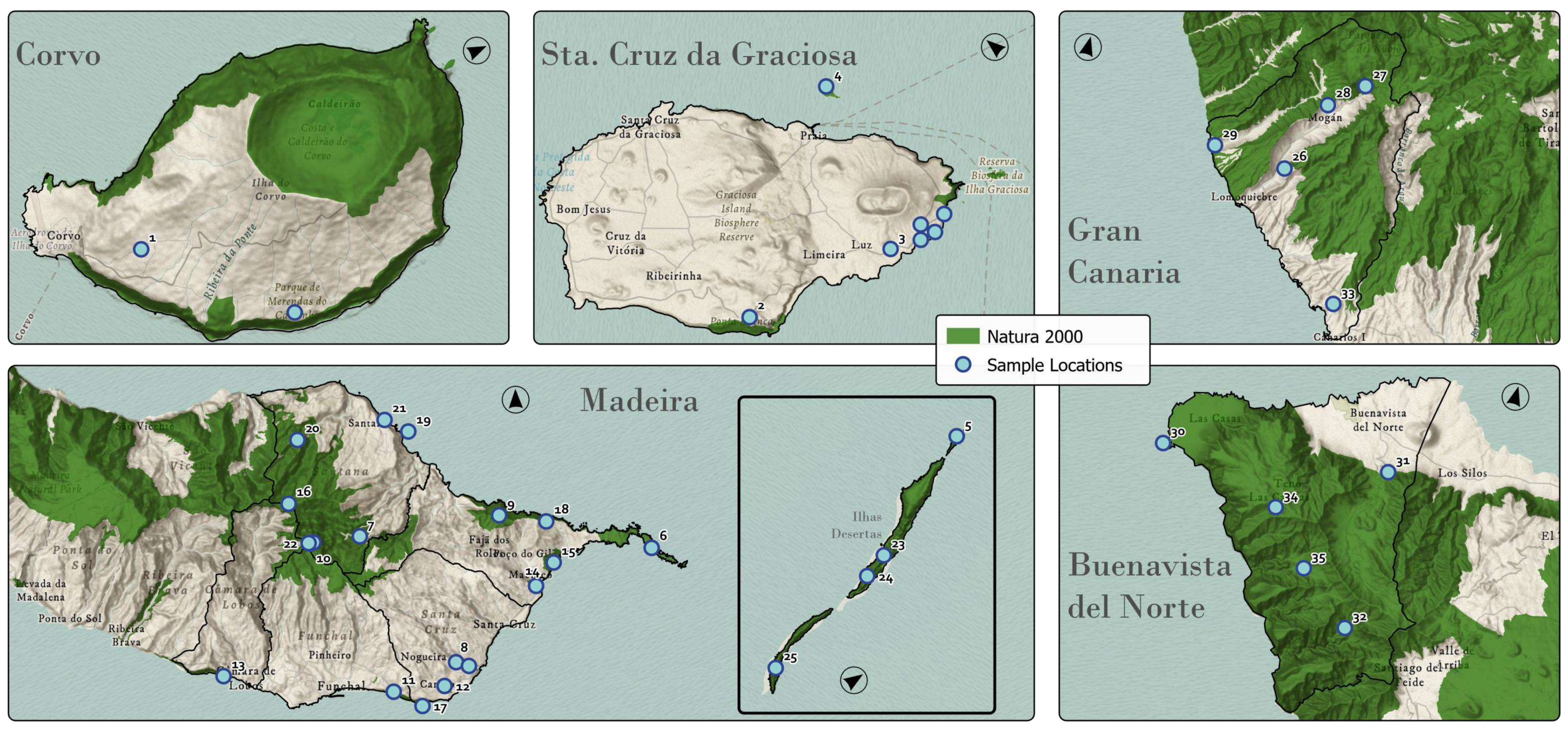
Artificial Light At Night (ALAN, also referred as Light Pollution) is a global concern affecting both health and biodiversity[1]. As such, there is an ongoing development in technology and methods (single-channel radiometry, satellite imaging analysis, and temporal monitoring) that have improved our understanding of light pollution to increase and implement mitigation efforts.

The project LIFE Natura@night is on this same track, creating light pollution spatial information and studying its relationship with biodiversity important sites[2] like the Natura 2000 Network (N2000) across the Macaronesia region, as it hosts important and vulnerable biodiversity. The objective was to identify artificial light sources that potentially affect biodiversity; these steps included field sampling photography and photometry across 20 Natura 2000 areas of Madeira, Graciosa and Corvo (for Portugal), and Gran Canaria and Tenerife (for Spain).

Methods

Objective: Evaluate and quantify night sky brightness and identify sources of light pollution in Natura 2000 areas.

Site Selection: Sampling sites were located at the Natura 2000 sites within target municipalities, away from roads or highways, in open space with no barriers.



Location of sampling points:

1 – AZO - Costa e Caldeirão - Corvo
2 – AZO – Ponta Branca - Graciosa
3 – AZO – Carapacho - Graciosa
4 – AZO – Ilhéu da Praia - Graciosa
5 – MAD – Ilhéu Chão
6 – MAD – P. de S. Lourenço
7 – MAD - Ribeiro Frio
8 – MAD – Porto Novo
9 – MAD – Porto da Cruz
11 – MAD – Pináculo
12 – MAD – Caniço de Baixo
13 – MAD – Cabo Girão
14 – MAD – Machico
15 – MAD – Pico do Facho
16 – MAD – Pico Ruivo
17 – MAD – Garajau
18 – MAD – P. de S. Lourenço 2
19 – MAD – Clérigos
20 – MAD – Ribeiro Bonito
21 – MAD – Ilhéu da Viúva
22 – MAD – Pico do Areeiro
23 – MAD –Deserta Grande 1
24 – MAD – Deserta Grande 2
25 – MAD – Bugio
26 – CAN – Macizo de Tauro
27 – CAN – El Nublo II
28 – CAN – Nublo IA
29 – CAN – Nublo IB
30 – CAN – Franja marina Teno-Rasca
31 – CAN – Teno
32 – CAN – Teno Masca
33 – CAN – Macizo de Tauro II
34 – CAN – Teno Alto
35 – CAN – Los Carrizales

Measurement Timing: To capture illumination over night, three time periods based on human activity and documented bird activity were defined: 19:00-21:00; 22:00-00:00; and 01:00-02:00. Adaptability was required due to unpredictable climate, sunset time variability and how much isolated the site was. Additionally, moon phases were considered, with a tolerance between the first and last quarter phases (50% of moon visibility).

Photometry and Photography: A DSLR camera with a fish-eye lens was used under four ISO & *f*-aperture settings. Photos were aimed at the zenith and the horizon on each cardinal point[3]. Secondly, a photometer, the "Telescope Encode Sky Sensor" (TAS), was balanced with a 20-degree field of view. The resulting photography was compared with brightness plots, providing visual and qualitative descriptions of the landscape. Observations focus on identifying light sources, monitoring changes over time, and assessing factors like humidity, moon visibility, and other data collection challenges.

Photography & TAS setup

Setup

Setup example in Bugio (Desertas islands), ideally both devices must be close to each other.

Change overtime

Top photo taken at 20:30 and bottom at 01:00. Differences in illumination were captured.

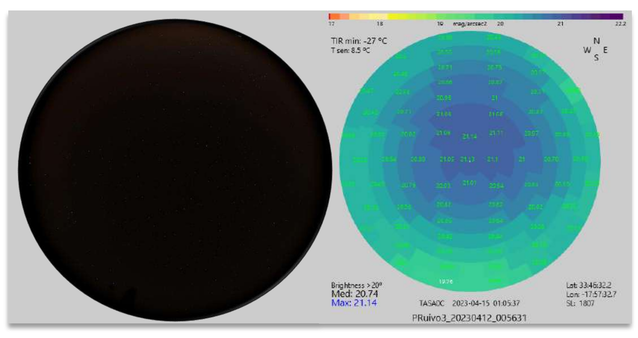
Azimuth photography

The Natura 2000 site and the city of Machico (Madeira island) are visible.

Results

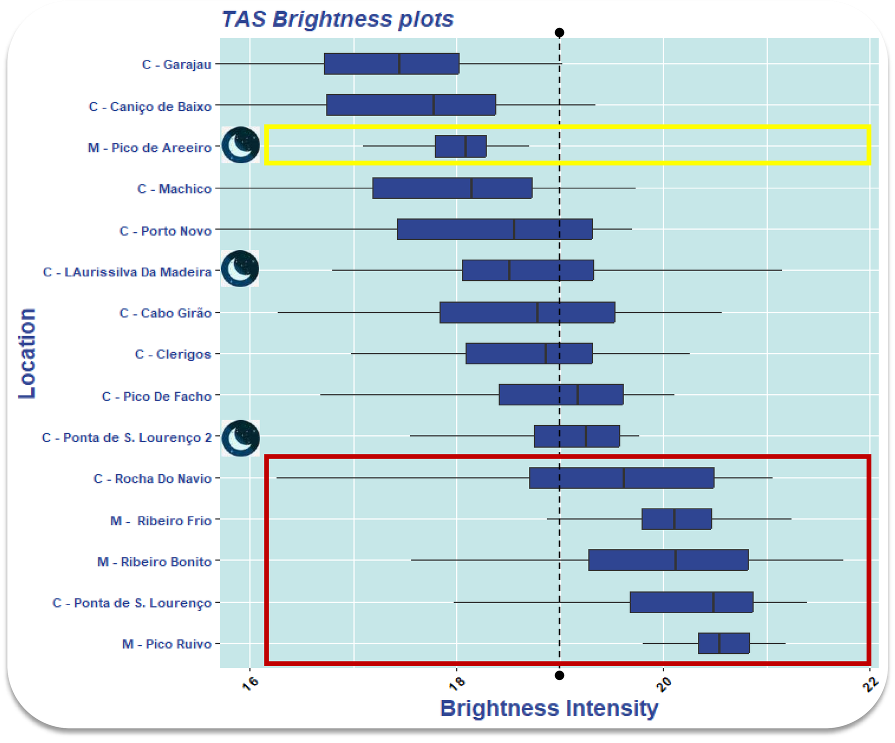
35 sites across the target municipalities were sampled, including 20 NT2000 sites (11 in Madeira, 4 in Azores and 5 in the Canary Islands); however, in some circumstances, it was impossible to be deep inside the NT2000. Other exceptions were Clérigos (Madeira), not N2000 but a seabird colony of interest, and Sta. Cruz da Graciosa was sampled in the pilot area in Carapacho, where public lights will be changed (data will be important for monitoring before/after effects of light changes).

Darkest areas

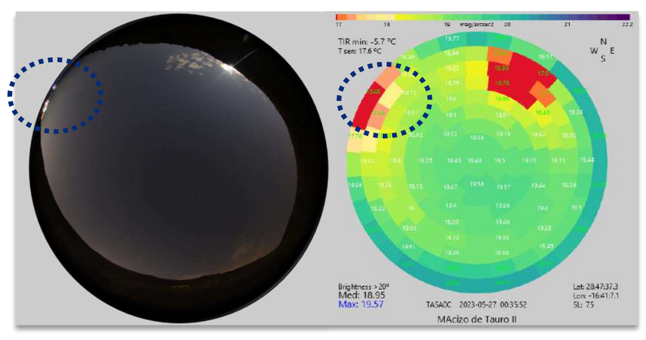


In Pico Ruivo (Madeira), it was possible to have the best-case scenario for the intended purpose of sky photography and TAS. The difference to the study's purpose was that capturing any town or city was impossible. Even with those conditions, these were not the darkest recorded scores in the study.

On Madeira island, **the darkest values were recorded in Pico Ruivo, Rocha do Navio, Ribeiro Frio, Ribeiro Bonito, Pico Ruivo and Ponta de São Lourenço**. These N2000 sites are in the center and coastal areas of the island.



Moon influence

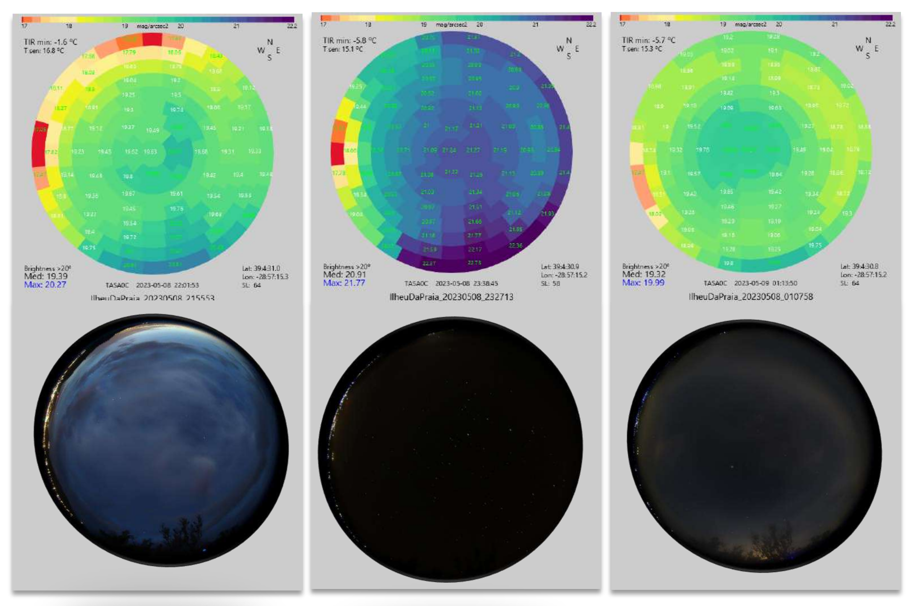


During the sampling in Macizo de Tauro II, the moon was present. With clear skies, its influence was very noticeable, which was not ideal for the TAS because **the brightness registered mainly was caused by moonlight**. Also, landscape photography showed plenty of details of the terrain as it was light. Fortunately, it was still possible to identify the primary ALAN source corresponding to some residential areas.

Low clouds & Humidity

Challenging environmental conditions were humidity, fog, and low clouds which affected TAS performance and brightness readings, especially if the moon had a slight presence.

The example in Ilhéu da Praia shows these effects in both TAS and photography: the first period (21:30) had expected brightness, and the second was logically darker, but in the last period, low clouds and fog were present, making the device not work and record incomplete plots. In the end, it is possible to see the increase in brightness.



Discussion

The LIFE Natura@night project tackles the pressing issue of light pollution's adverse effects on both human well-being and biodiversity on a global scale. **Focused on the Macaronesia region and Natura 2000 network, this study aimed to assess and quantify night sky brightness while pinpointing sources of light pollution within these areas.** It employed a comprehensive methodology with rigorous requirements and a flexible approach due to unpredictable environmental conditions to achieve the goal. Photometry and photography served as integral data collection methods. The landscape photography perspective, light sensitivities configuration, and the (TAS) photometric measurements served their purpose in this research, showing ALAN sources impacting N2000 sites. That is even while used in unfavorable conditions for the original intended use of the device.

We can conclude that **the methodology implemented here successfully mapped and recorded the current state of brightness in N2000 sites.** At the same time, there were some drawbacks during data collection. The standard sky brightness measurement with photometers requires strict, clean environmental conditions that were often unmet thanks to humidity, fog, low clouds and rain. In some instances, those conditions caused the device to fail; other times, it seemed to increase light dispersion; therefore, the plots had higher brightness scores (either by the moon's or urban light's presence)[4]. Finally, it is essential to emphasize that even though it was considered that climatic conditions were representative and ALAN sources tended to be fixed objects, these measurements only describe the conditions found at that point in time, and they do not represent the average or most common condition during the year. While the objective was accomplished, further monitoring is needed in the following years, especially on sites where pilot projects to change public illumination are currently taking place.

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For more information, visit https://naturaatnight.spea.pt/.

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