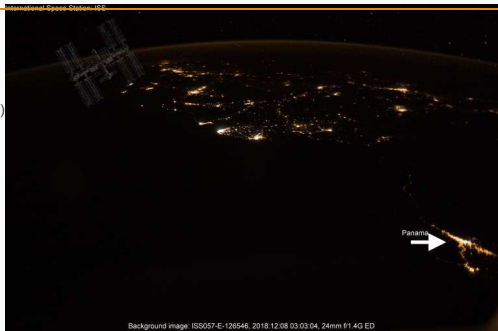


First Light Pollution Monitoring Station in Panama: Integrating Ground-Based and Remote Sensing Techniques

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California, USA



Why Light Pollution Matters in the Tropics?

- No previous monitoring of brightness, color, and spectrum ground-based data exists for the country or in Central America.
- Light scattering behaves differently than in large urban centers in developed countries.
- Excessive nighttime brightness affects the behavior of bats, moths, migratory birds, and insects.
- Blue-rich LEDs increase attraction, disorientation, and habitat fragmentation.
- The Canal basin mixes forest, port, and urban zones with high ecological sensitivity.
- Quantitative measurements of brightness, color, and spectrum are needed to understand impacts.

Ground-Based Observations

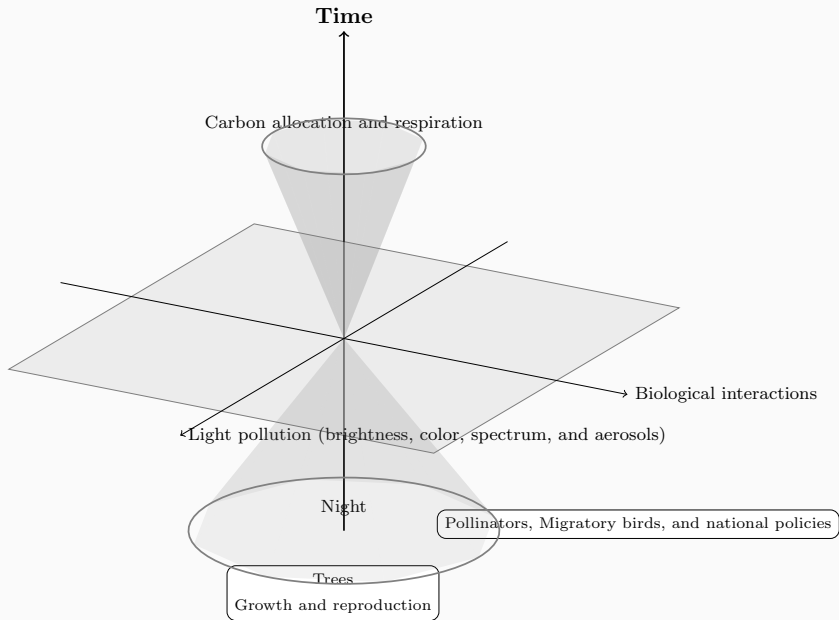
- Photometry: all-sky images and zenith night sky brightness (mag arcsec^{-2}).
- Spectrometry: 375nm in the near UV to 750 nm in the near IR.
- Droplet size distribution (mm).

Remote Sensing

- Drone: high-intensity source identification.
- ISS imagery: full color information.
- VIIRS / DMSP-OLS: calibrated upward radiance.
- AVIRIS-NG: mapping of streetlight sources.

- **Ground-Based:**
- QHY calibrated all-sky imaging (UBVRI)
- Nikon D5600a (RGB)
- TESS-W and 4C
- TASS photometer
- ALPY spectrometer
- OTT laser disdrometer
- **Remote Sensing:**
- ISS imagery (International Space Station)
- VIIRS and DMSP-OLS
- Drone
- AVIRIS-NG (Day-Night image, Feb 2025).

Research: Interdisciplinary Nature



Objective.

- The objective of this research is to establish the first light pollution monitoring station in the Republic of Panama.

Research Question.

How do light pollutants interact with nocturnal pollinators at the forest-urban interface in the Panama canal route?.

Sampling Locations



Ground-Based: INDICATIC-UTP



Ground-Based: Interoperability, Data Integrity, and Security.

<https://github.com/INDICATIC-AIP/Ground-based>

* Master's thesis: Alexandre Oliivié. Bordeaux, INP, Enseirb-matmeca.

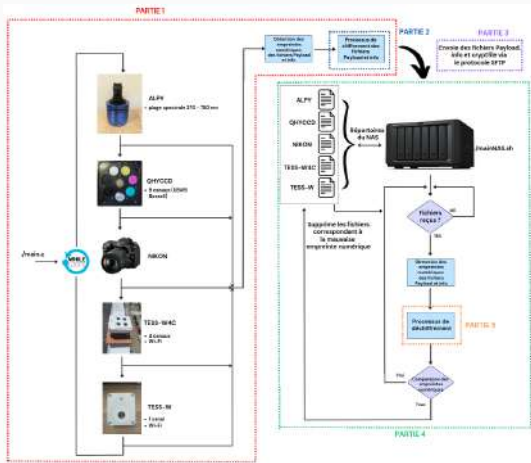


FIGURE 5 – Vue d'ensemble du fonctionnement du code d'interopérabilité

Ground-Based: Interoperability, Data Integrity, and Security.

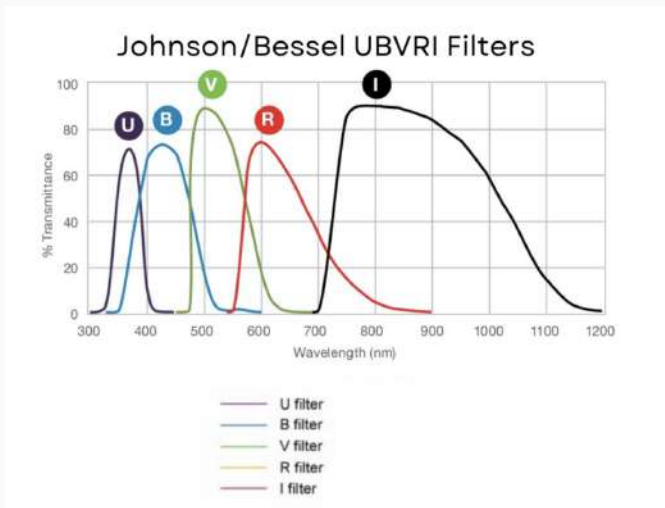
<https://github.com/INDICATIC-AIP/Ground-based>

* José Cornó (Japan), former assistant, Chiba University and Alexandre Olivie.



Ground-Based: QHY16200a Transmission Channels

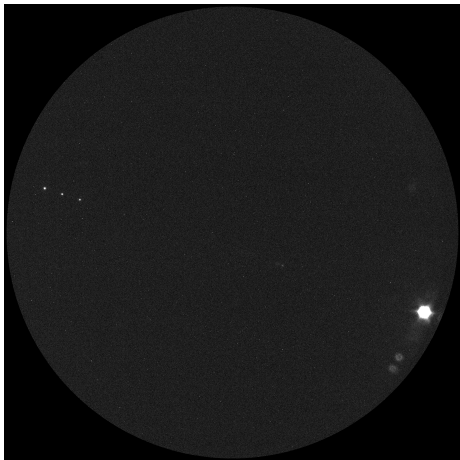
<https://store.andovercorp.com/product-category/johnson-bessel-ubvri-filters/>



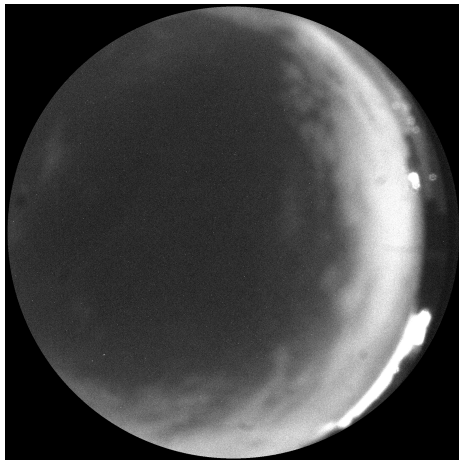
Ground-Based: QHY Camera

February 13, 2026, 20:26 (Panama).

Johnson U

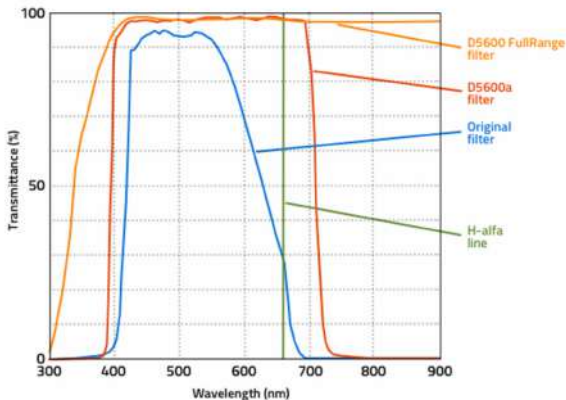


Johnson B



Ground-Based: Nikon D5600a Transmission Channels

<https://www.astroshop.eu/astromodified-dslr-dslms/nikon-camera-dslr-d5600a/p,53133>



Ground-Based: Nikon D5600a

Nikon D5600a, NIKKOR 10.5 mm f/2.8G diagonal fisheye (180° diagonal), ISO=100, exposure time=10 s, site: Pacific, 2026-02-14/19:08, pointing (zenith).



NEF image
Raw view



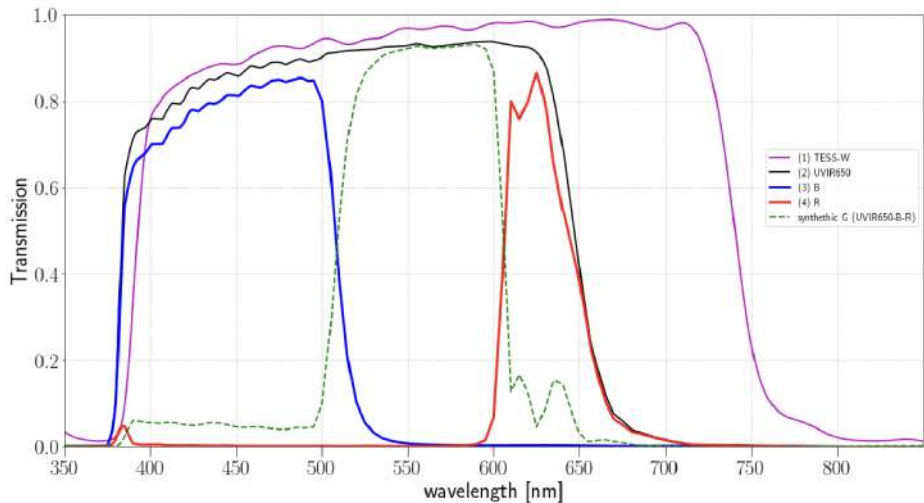
Demosaiced RGB



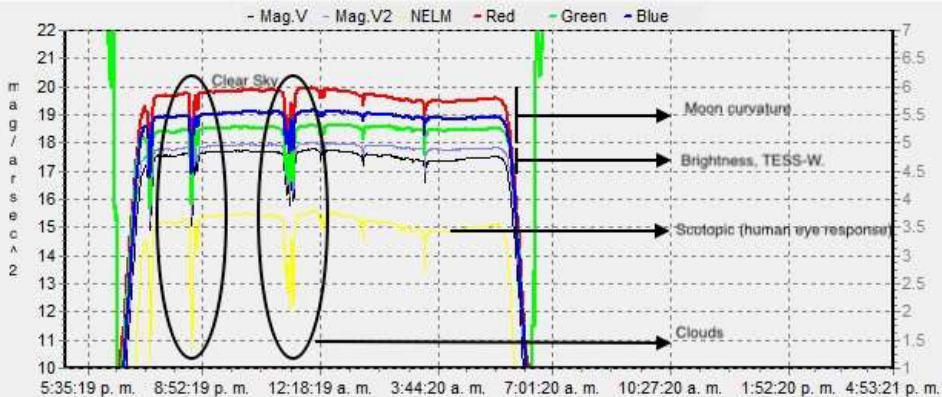
Elevation $\geq 30^\circ$
Controlled analysis region

Ground-Based: TESS-4C Transmission Channels

https://guaix.fis.ucm.es/~jaz/TESS-4C/report_LICA_TESS-4C_filters_202205_V1.pdf



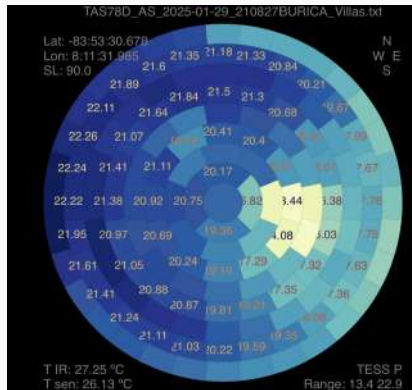
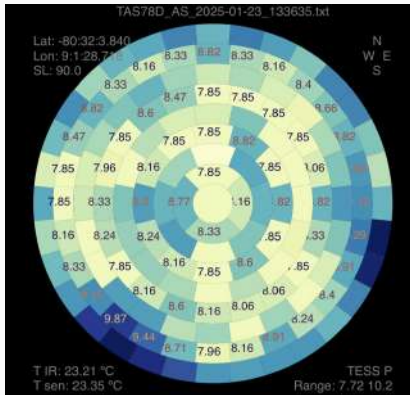
Ground-Based: TESS-4C Photometer



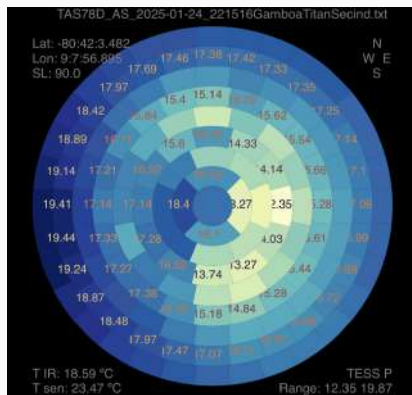
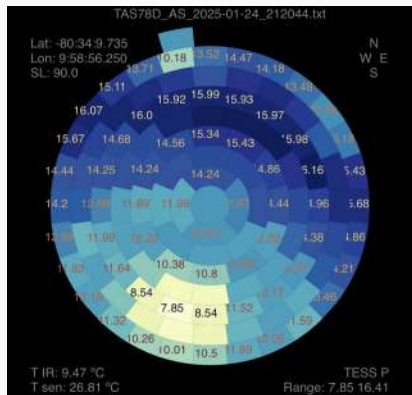
<https://tess.dashboards.stars4all.eu/d/0gUheXrnk/tess-4c?orgId=1&var-TessMC=stars1315&from=now-2y&to=now>

<https://tess.dashboards.stars4all.eu/d/0gUheXrnk/tess-4c?orgId=1&var-TessMC=stars1315&from=now-2y&to=now>

Ground-Based Preliminary Data (TASS): Baseline.



Ground-Based And Preliminary Data (TASS): Balboa And Gamboa.

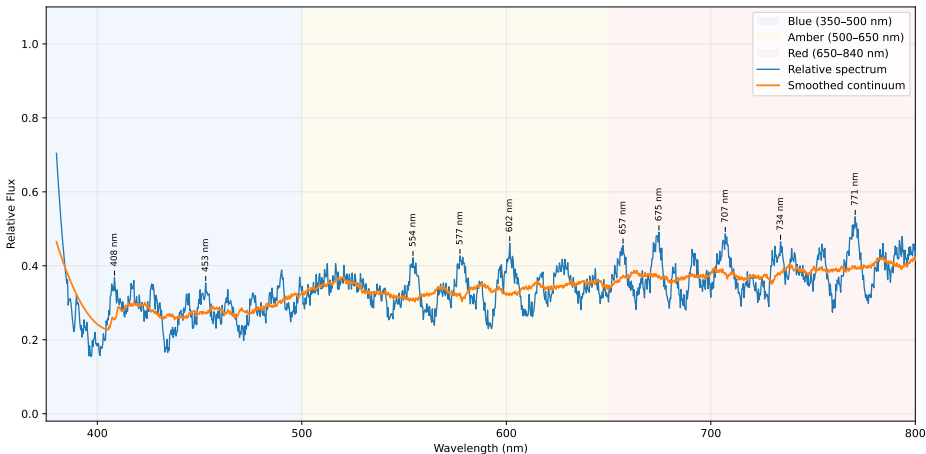


Ground-Based: Panama City Nighttime Image



Ground-Based, ALPY Spectrometer (uncalibrated), Panama

25 μm from near UV to near infrared

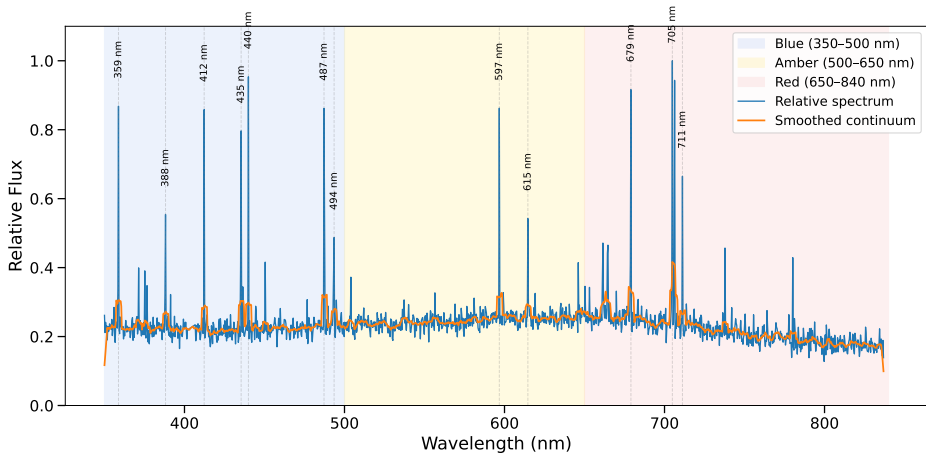


Ground-Based: Reference Night Sky Image (Nikon D5600a)



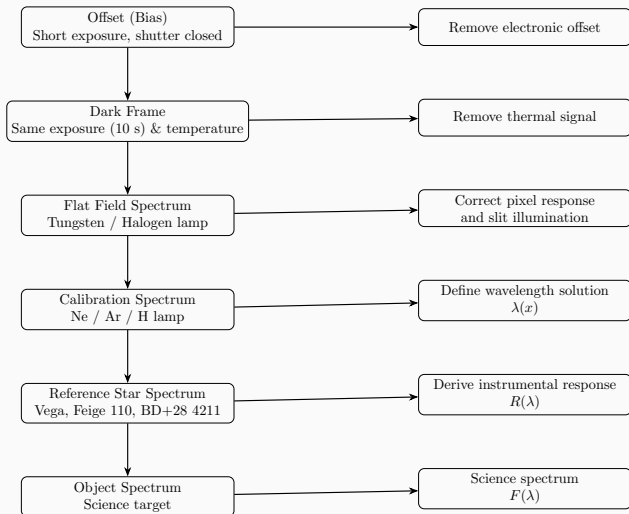
Autor: José Robles, ISO 5000, 30 segundos de exposición, Mariato, Punta Duarte, Veraguas, Panamá. 21

Ground-Based, ALPY Spectrometer (calibrated), Punta Duarte, Mariato



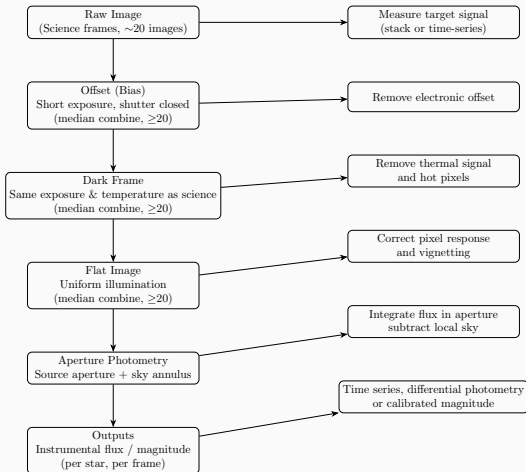
ALPY: Calibration

Object image + offset + darkframe + flat fields + Calibration lamps and laser. 20 images.

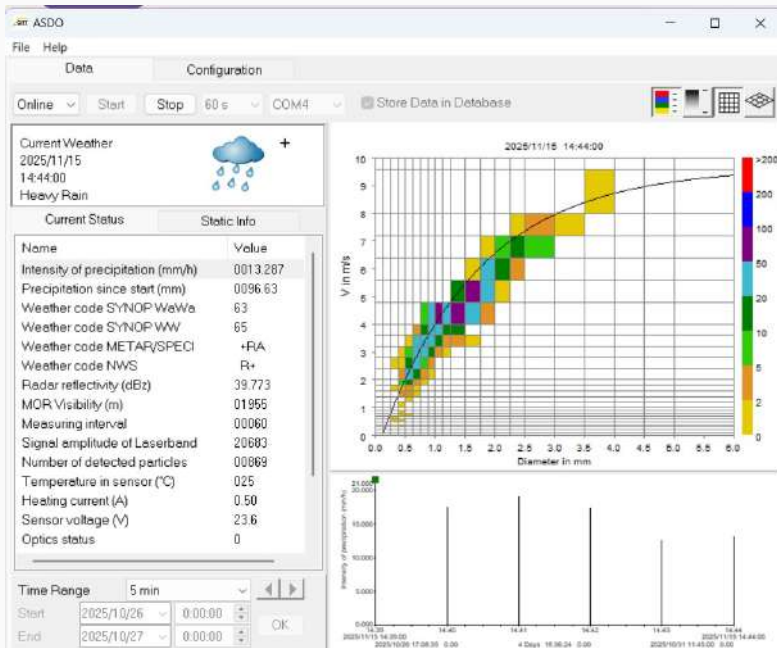


QHY 16200A and Nikon D5600a: Calibration

Raw image + offset + dark frame + Flat image + Aperture photometry. +
20 images and 10 s.



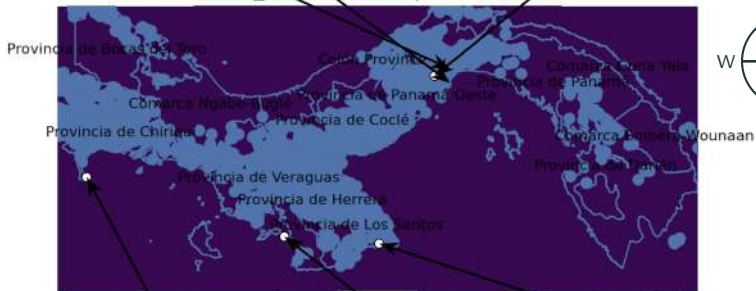
Ground-Based: OTT Disdrometer (Secondary Data)



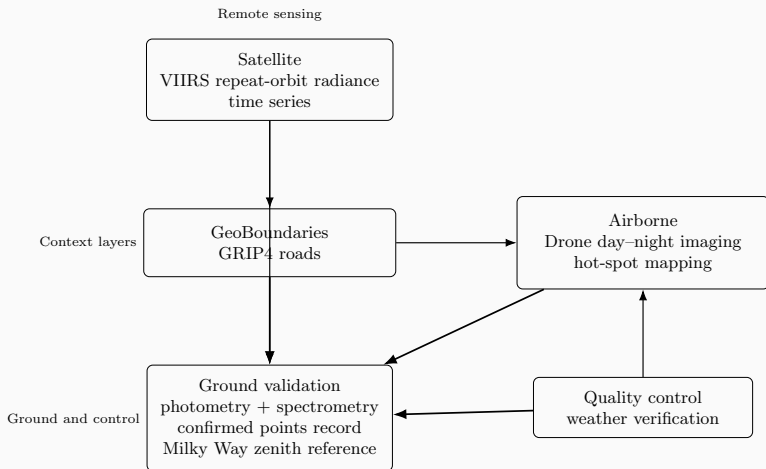
Ground-Based: Baseline Night Sky Quality



noaa_20250301.tif | 2025-03-01

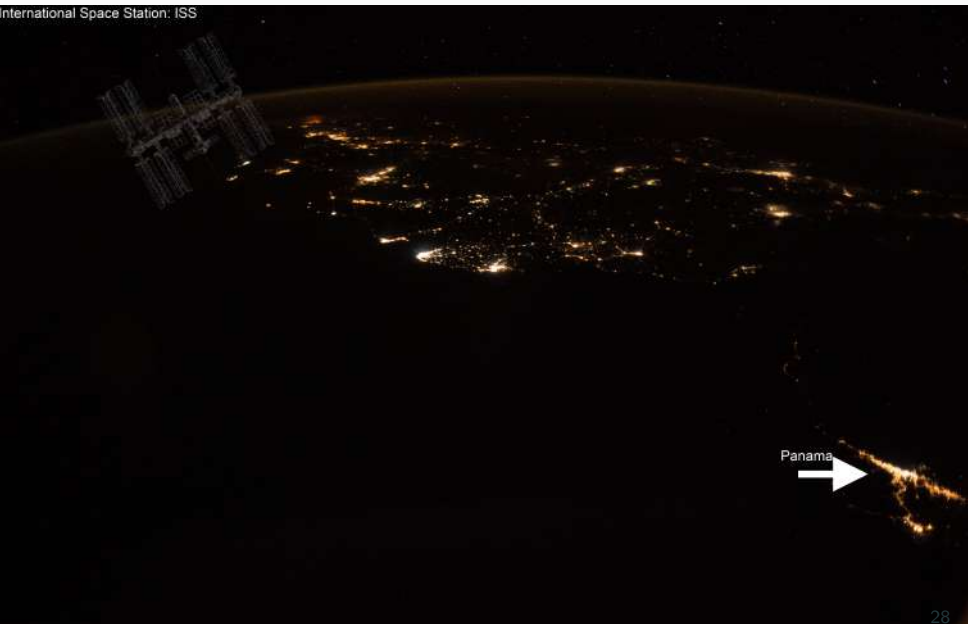


Ground-Based: Baseline Night Sky Quality



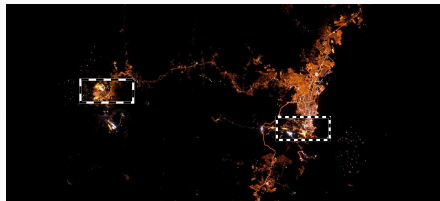
Remote Sensing Techniques

International Space Station: ISS



Background image: ISS057-E-126546, 2018:12:08 03:03:04, 24mm f/1.4G ED

Remote Sensing Techniques: ISS Imagery.

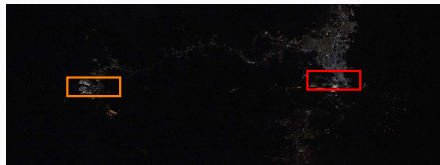


(a)



(b)

Figure 1: Luminarias de Panamá en 2012. ISS072-E-797729.



(a)



(b)

Figure 2: Luminarias de Panamá en 2025. ISS030-E-167962

Remote Sensing Techniques: ISS, VIIRS, and DMSP OLS Imagery System

* Bachelor's thesis: José Jaén (Universidad Tecnológica de Panamá, UTP). <https://github.com/INDICATIC-AIP/Remote-sensing>.

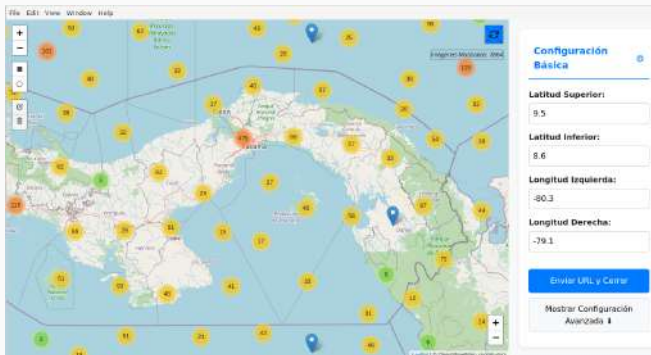
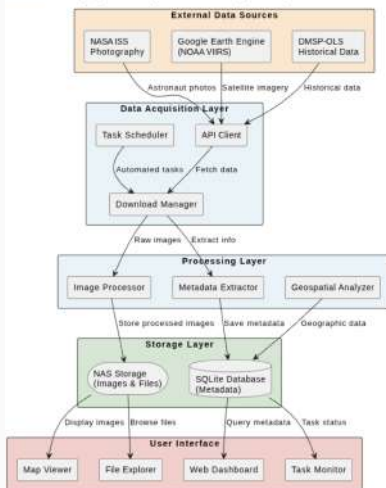


Figura 4.18: Pantalla principal de la interfaz desarrollada con Electron. Se

Remote Sensing Techniques: ISS, VIIRS, and DMSP OLS Imagery System

<https://github.com/INDICATIC-AIP/Remote-sensing>.

Remote Sensing System for Light Pollution Analysis - Simplified Architecture

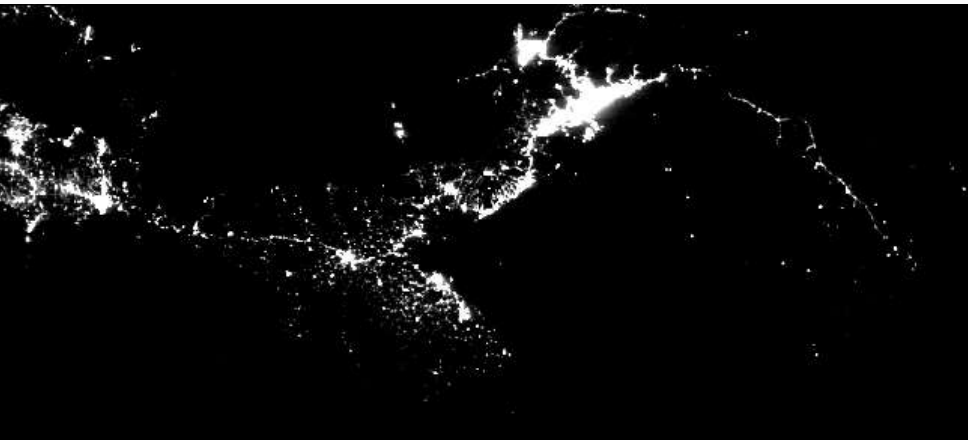


Remote Sensing Techniques: VIIRS Imagery, 2013-01.



<https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/viirs/>

Remote Sensing Techniques: VIIRS Imagery, 2016-01.



<https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/viirs/>

Remote Sensing Techniques: VIIRS Imagery, 2021-01.



<https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/viirs/>

Remote Sensing Techniques: VIIRS Imagery, 2025-01.



<https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/viirs/>

- Coordinated day–night hyperspectral campaign.
- Partial nighttime spectral inventory of streetlight sources.
- Daytime reflectance characterization of materials and urban–tree interfaces.
- Spectral diagnostics data to support Panama’s emerging nighttime illumination policy (in coordination with MiAmbiente).
- Identification of neighborhood-scale light pollution hotspots.

*Elvidge et al. (2024); Kruse et al. (2011); Kruse (2012).

Panama: Draft Light Pollution Policy Framework

- Institutional coordination with MiAmbiente (Ministry of Environment of Panama).
- Technical guidance from the National Policy Directorate.
- Draft regulatory framework for nighttime illumination (under review).
- National Scientific Committee established to provide evidence-based recommendations.
- Ongoing development of scientific criteria and environmental impact metrics.

Energy efficiency addresses consumption. Environmental integration addresses ecological and health consequences.

Integrating Measurements With STRI

- Future deployment of a light pollution sub-station near Gamboa. BatLab: Dr. Rachel Page.
- Fieldwork in visible-band photometry.

Ecological Link: Nocturnal Pollinators And Other Species





- Photometry and spectrometry changes influence flight-path decisions.
- Ongoing selection of focal species (bats, moths, and spiders).
- Other data use: migratory birds (requires international efforts).
- Goal: quantify behavioral change under measured light regimes.




- INDICATIC, Dr. José Robles.
- Smithsonian Tropical Research Institute, STRI, BatLab, Dr. Rachel Page.
- Universidad Complutense de Madrid, UCM, Dr. Jaime Zamorano and Sergio Pascual.
- Universidad Tecnológica de Panamá, UTP, Dr. Alfredo Campos, Reinhardt Pinzon, and Franchesca González.

Outlook

- Deployment of a permanent monitoring sub-station at the Pacific entrance of the Panama Canal.
- Completion of the first fully calibrated radiometric dataset (Nikon + TASS + TESS).
- Identification of dominant nighttime illumination focal points relative to Milky Way visibility.
- Expansion of collaboration on tropical nocturnal ecology and lighting regulation.
- Commitment to open-source tools and open-data dissemination.

Thank you.

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-  Johnston, A. S., Kim, J., & Harris, J. A. (2025). **Widespread influence of artificial light at night on ecosystem metabolism.** *Nature Climate Change*, 1–7.
-  Kyba, C., Ruhtz, T., Fischer, J., & Hölker, F. (2012). **Red is the new black: How the color of urban skyglow varies with cloud cover.** *Monthly Notices of the Royal Astronomical Society*, 425, 701–708. <https://doi.org/10.1111/j.1365-2966.2012.21559.x>

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<https://doi.org/10.3390/rs13081511>
-  Sánchez de Miguel, A., Kyba, C. C., Aubé, M., Zamorano, J., Cardiel, N., Tapia, C., Bennie, J., & Gaston, K. J. (2019). **Colour remote sensing of the impact of artificial light at night (i): The potential of the international space station and other dslr-based platforms.** *Remote Sensing of Environment*, 224, 92–103. <https://doi.org/https://doi.org/10.1016/j.rse.2019.01.035>
-  Shivanna, K. (2022). **Impact of light pollution on nocturnal pollinators and their pollination services.** *Proceedings of the Indian National Science Academy*, 88(4), 626–633.



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<https://doi.org/https://doi.org/10.1016/j.mambio.2015.02.004>



Voigt, C. C., Dekker, J., Fritze, M., Gazaryan, S., Hölker, F., Jones, G., Lewanzik, D., Limpens, H. J., Mathews, F., Rydell, J., et al. (2021). **The impact of light pollution on bats varies according to foraging guild and habitat context**. *BioScience*, 71(10), 1103–1109.