Methodology

This document explains how nightly VIIRS DNB data are transformed into clean, comparable municipal time series of nighttime luminosity, the data filters applied to ensure like·for·like comparisons, and the methods used to compare levels across time in the plots.

1. Objectives

1 Produce reliable daily luminosity measures per municipality and country from satellite radiance and cloud masks.
2 Prioritize measurement quality (clouds, moonlight, swath artifacts, contamination) for robust temporal comparisons.
3 Provide interpretable comparisons across time (YoY, YTD, QTD, peak·vs·peak, monthly averages) and spatial change maps.

2. Data Source and Inputs

The pipeline uses NASA's **VNP46A1** product (VIIRS/NPP Daily Gridded Day Night Band, Collection 5200) from the LADSWEB archive. This replaced an earlier reliance on the Earth Observation Group (EOG) rade9d product hosted at the Colorado School of Mines.

- **Product:** VNP46A1 · nightly at·sensor radiance on the MODIS sinusoidal tile grid.
- **Spatial resolution:** 15 arc·seconds (~500 m at the equator), distributed as HDF5 files.
- **Bands used:** (1) DNB_At_Sensor_Radiance (nW/cm²/sr); (2) a cloud mask derived from the QF_Cloud_Mask quality flag. Both are reprojected to EPSG:4326 GeoTIFF for processing.
- **Lunar filter:** dates with lunar illumination above a configurable threshold (default · 20%) are excluded before processing to reduce moonlight contamination.

Country and municipality boundaries define the spatial units of measurement; all metrics are computed within these polygons.

3. Per·Day Measures (by Municipality)

For each date and municipality, the dataset records:

- Luminosity: summed radiance over the municipality polygon.
- Cloud fraction: share of pixels flagged as cloudy within the polygon.
- Lunar conditions: lunar elevation (degrees) and fraction illuminated (%) at the municipal centroid (UTC midnight).
- Swath overlap flag: indicates whether the polygon intersects a detected swath·edge artifact in the nightly raster.

At the country level, a median luminosity check is used as a contamination safeguard. These measures feed the daily panel for each municipality.

4. Data Quality Screening

To ensure comparability across dates, the following records are excluded:

- Any municipality·day with cloud cover (cloud fraction > 0).
- High·moonlight conditions (e.g., lunar illumination > 30% for tabular export; a stricter · 10% when selecting imagery/videos).
- Municipality·days intersecting swath·edge artifacts.

● Entire country·days whose median luminosity is non·positive or exceeds a contamination threshold.

The retained observations are exported as tidy per·municipality CSVs containing dates, luminosity, and the key covariates.

5. Time Series Assembly and Visual Artifacts

● Daily municipal records are ordered chronologically to form the time series; missing dates remain missing (no imputation), reflecting actual observation availability after quality filtering.
● For spatial context, ·earliest· and ·latest· country composites are built by averaging multiple suitable nights in each period and masking to the country polygon. A difference image (latest minus earliest) highlights where luminosity increased or decreased.

6. Temporal Comparison Methods

These methods are designed to reduce noise, respect seasonal patterns, and retain interpretability.

6.1 LOESS Smoothing (Trend Extraction)

Locally weighted regression (LOESS; bandwidth 0.25) is applied to the uneven daily series to extract a smooth trend. This reduces day·to·day variability from residual clouds, sensor noise, or moonlight, making level comparisons more stable.

6.2 Year·over·Year (YoY) Percent Change

Compare the latest smoothed value to the smoothed value at the closest date one year earlier:

(latest · prior_year) / prior_year $\times$ 100

This aligns seasonally comparable dates and mitigates seasonal activity cycles.

6.3 Year·to·Date (YTD) and Quarter·to·Date (QTD)

YTD compares the latest smoothed level to the smoothed value on January 1 of the current year. QTD compares to the smoothed value on the first day of the current quarter. These emphasize intra·year progression relative to standard baselines.

6.4 Peak·vs·Peak in N·Day Windows (on LOESS)

To assess changes around activity peaks, the plots show the maximum smoothed value within an N·day window near the latest date versus the maximum smoothed value within an equal N·day window centered one year earlier. The percent change between these two peaks summarizes how the typical crest shifted year·over·year. (In practice, N is commonly 60 days.)

6.5 Monthly Averages

Daily observations are aggregated to calendar·month averages and plotted as bars beneath the LOESS trend, providing coarse seasonal context and stabilizing interpretation over longer spans.

6.6 Spatial Difference Maps (Before vs After)

For spatial change, two composites (earliest vs latest) are formed by averaging suitable nights in each period and masking to the country polygon. Subtracting earliest from latest yields a difference map, rendered with a diverging palette to show increases vs decreases. Extreme values are clipped to reduce the influence of a few outliers.

7. Design Rationale

- Quality·first selection ensures like·for·like comparisons by removing cloud, moonlight, swath, and contamination issues.
- LOESS provides a robust, non·parametric trend for uneven, noisy daily data.
- Multiple baselines: YoY aligns seasons; YTD and QTD summarize intra·year momentum; peak·vs·peak highlights shifts around typical highs; monthly averages add seasonal context; spatial diffs show where change occurs.

8. Key Parameters

- LOESS bandwidth: 0.25.
- Lunar illumination thresholds: typically · 30% for tabular export and · 10% for imagery/video selection.
- Peak windows: N·day windows (commonly 60 days) around the latest date and the year·earlier anchor.
- Earliest/latest separation: at least one year for spatial composites.
- Difference image clipping: extremes clipped to reduce the effect of outliers.

9. Limitations and Considerations

- Clear·sky, low·moonlight requirements can reduce observation density in some seasons/regions.
- LOESS can attenuate abrupt shocks; peak comparisons and monthly bars support interpretation but involve sensitivity vs noise trade·offs.
- Spatial difference magnitudes depend on the number and spacing of nights included in each composite.

10. Outputs and Visualizations

- One CSV per municipality with cleaned daily luminosity and covariates (date, cloud, lunar metrics, swath flag).
- Charts show raw points, the LOESS trend, and monthly averages; summary tiles report YoY, YTD, QTD, and peak·vs·peak changes based on the smoothed series.
- Country·level lightbox images (averaged earliest/latest) and a per·pixel difference map depict spatial shifts in luminosity.