VIIRS Night-Time Light Sensing & Application

Image Processing for Earth Observation

Ching-Chi Chou, Kaile Chu, Bich Ngoc Doan

Introduction to Night-Time Light

Nighttime light remote sensing refers to the capture of visible light at night, including both natural and artificial sources such as city lights and streetlights. It is widely used as a primary data source for measuring large-scale human activities.

Applications include assessing electricity consumption, monitoring light pollution, and studying urban ecosystems. The **Visible Infrared Imaging Radiometer Suite (VIIRS)** is crucial for collecting accurate nighttime imagery due to its **high spatial resolution** and **sensitivity to low light** levels.

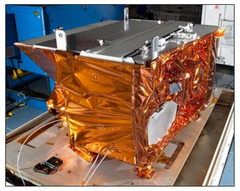


Image 1. & 2. Visible Infrared Imaging Radiometer Suite (VIIRS). NASA Science & Office of Satellite And Product Operations (2011).

Parameter	Specification
Platform	Polar-orbiting, sun-synchronous satellites
Orbit Altitude	824 kilometers
Swath Width	3,000 kilometers (provides near-global coverage every 12 hours)
Spatial Resolution	- I-bands: 375 m - M-bands: 750 m - Day/Night Band (DNB): 750m
Spectral Bands	22 Spectral Bands - 5 I bands and 16 M bands for surface, vegetation, snow, cloud, atmosphere, etc. - Day/Night Band (0.5-0.9μm) for ultra-sensitive low-light imaging
Revisit Time	Twice Day (Ascending and Descending orbits for Day and Night Observations)

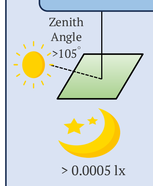
I bands provide higher resolution and cover visible to thermal infrared wavelengths, while **M bands** offer moderate resolution across a broader range from deep blue to thermal infrared. **DNB** covers visible and infrared spectral ranges.

*Image 3 3D rendering of Europe Night-Time Light **

Procedure for Generating VIIRS Night-Time Lights

To produce VIIRS nighttime light data, a sequence of filtering steps is applied to remove various types of unwanted artifacts.

Data Processing

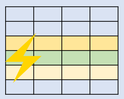


Sunlit, **Moonlit**, and **Stray Light** data are filtered out to prevent noise. A stray light correction is applied in mid to high latitudes to avoid stray light contamination.

Artifact & Cloud Detection

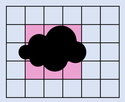
HEP Detection

Radiance Differences (A,P_{1234}) are calculated to filter out the pixels affected by High Energy Particle



Lightning Detection

Calculate the Radiance Differences between adjacent rows of 16-Line Sweep Scans to detect lightening



Cloud Screening

VIIRS cloud mask (VCM) are used to screen out pixels deemed to be clouds

Background Radiance

Compute Local Background by the mean radiance of neighboring pixels by 3x3 kernel to define background radiance

Adaptive Thresholding to identify pixels where the radiance significantly exceeds the local background, which helps detect genuine light sources while minimizing false positives.

Integration & Analysis

Combine processed nighttime light data with land cover information, population data, etc., to enhance analysis accuracy. To understand human settlement distribution and urbanization trends, spatial analysis is often used to investigate the distribution patterns

An Example of VIIRS Light-Time Light Application

Satellite nighttime light data from VIIRS sensors, such as the one installed on the Suomi-NPP satellite, have been observed to correlate with socio-economic activities in urban areas (e.g., cities in China).

Ma et al. (2014) investigated how night-time light emission is correlated with urbanization variables (e.g., population, GDP, power consumption and infrastructure, and airport traffic). This study demonstrates that VIIRS data can effectively capture socioeconomic dynamics at a finer scale than previous methods.

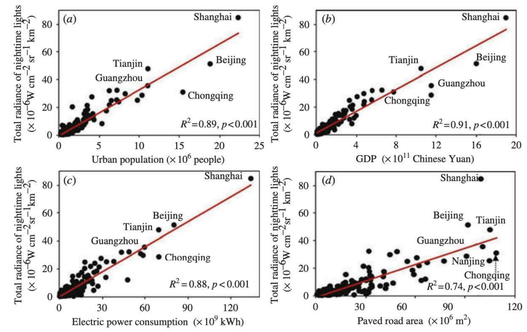


Figure 1 Statistical relationships between average nighttime light radiance(a) GDP per unit urban area and (b) urban population density. Statistical relationships between proportion of area with intense lighting and (c) GDP per unit urban area and (d) urban population density. Ma et al.(2014)

Challenges and Provisions

The application of VIIRS nighttime light data, i.e. DSMP, OLS, faces challenges such as filtering out the noises and complicated procedures to define the background radiance. Despite these issues, VIIRS remains a powerful tool due to its high sensitivity, frequent revisit times, and global coverage.

It has broad applications in urbanization research, environmental monitoring, and socioeconomic studies, offering valuable insights into human activity and development patterns on a global scale.

References

1. Elvidge, C. D., Baugh, K., Zhizhin, M., Hsu, F. C., & Ghosh, T. (2017). VIIRS night-time lights. International journal of remote sensing, 38(21), 5860-5879.
2. Ma, T., Zhou, C., Pei, T., Haynie, S., & Fan, J. (2014). Responses of Suomi-NPP VIIRS-derived nighttime lights to socioeconomic activity in China's cities. Remote Sensing Letters, 5(2), 165-174.

Image 3 was made utilizing VIIRS Nighttime Light (VNL) data produced by the Earth Observation Group, Payne Institute for Public Policy, Colorado School of Mines.