

Intercalibration of DMSP-OLS and NPP-VIIRS to Develop Enhanced Night-time Light Time-series for Evaluating the Urban Development Pattern of Major Indian Metropolitan cities

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Abstract

Defense Meteorological Satellite Program-Operational Line scan System (DMSP-OLS) and Suomi National Polar-orbiting Partnership-Visible Infrared Imaging Radiometer Suite (NPP-VIIRS) night-time light (NTL) datasets portraying nocturnal lit pixels have been widely applied to effectively monitor anthropogenic activities, temporal variation in urbanization, and assessment of the dynamics of socio-economic activities and development. Among the various challenges in conventional NTL remote sensing studies, one has been the development of a consistent and long-term NTL time series dataset, indispensable for extended duration analysis. Lack of onboard-calibration, low spatial and radiometric resolution causing saturation for dense urban built up and blooming effect exaggerating the urban extent; pose challenges in the efficient use of DMSP-OLS (2.7 km) data for urban development studies despite its availability since 1992. Therefore, this study attempts to generate high resolution enhanced DMSP-OLS dataset which could generate long-term and consistent NTL time series (1992-2021), intercalibrating with NPP-VIIRS (500 m) products considering invariant pixels. Considering NPP-VIIRS data as base, enhanced DMSP-OLS data are simulated for the period 2012-2013 (common to both retrieved datasets). Calibration of remaining DMSP-OLS datasets is performed utilizing the simulated products (for 2012, 2013) and taking advantage of neighborhood layers. Consequently, a consistent and more accurate NPP-VIIRS like NTL time series is achieved for the entire period overcoming the issue of saturation and blooming effects for DMSP-OLS products. The developed NTL time series is then used to study the urbanization patterns for major Indian metropolitan cities of Delhi, Mumbai, Chennai, and Kolkata. A significant increase in urbanization has been observed with decadal growth rate ranging from 20 to about 40 percent in the 30-year study period, depicting maximum growth proportion during the second decade, for majority of the cities. Further, adopting machine learning approach, Landsat 5 and 8 images have been classified to extract urban extent for the designated period and validate the intensity of urban development derived through NTL products. Keywords: Night-time lights, DMSP-OLS, NPP-VIIRS, urban growth



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Introduction

This study emphasises to understand the pattern of urban development in four different major metropolitan cities of India by exploring the potential of multi-resolution night time light (NTL) datasets available in public domain.



Data and Methodology

S. No.	Data	Source
1.	DMSP-OLS	National Oceanic and Atmospheric Administration (NOAA)
2.	SNPP-VIIRS	National Oceanic and Atmospheric Administration (NOAA)
3.	Landsat	United States Geological Survey(USGS)
4.	Ancillary Data	Google Earth Engine

DMSP-OLS: Defense Meteorological Satellite Program-operational line scan
SNPP-VIIRS: Suomi National Polar-orbiting Partnership's Visible Infrared Imaging

Calibration

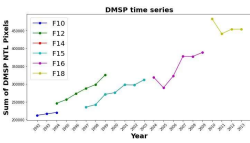


Figure 3: Uncalibrated DMSP Night time Light (NTL) time series for Chennai city

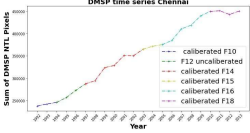


Figure 4: DMSP NTL time series after calibration for Chennai city

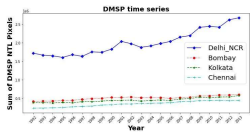


Figure 5: Calibrated DMSP NTL time series for all cities

Results



Figure 7: Before and after calibration of DMSP image of Chennai in year 2011



Figure 8: Before and after calibration of DMSP image of Chennai in year 2001

Validation

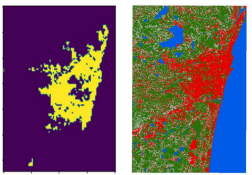


Figure 11: Validation between final enhanced VIIRS like DMSP 1992 image and LULC - 1992

Conclusion

- There is a significant over estimation of night time light by coarser resolution DMSP sensors, which could be efficiently corrected by cross calibrating with the finer resolution VIIRS data products.
- It was observed that all the cities have significantly expanded in 30 years study period. However, the rate of urban expansion in NCR (Delhi) and Chennai is comparatively more.
- Moreover, there is further scope to improve our results by incorporating more advanced techniques to cross calibrate the different datasets.