Maintenance and Continuation of NASA's Black Marble Nighttime Lights Product Suite

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Product Overview

NASA has developed a global suite of standard products that represent the current state-of-the-art in nighttime lights (NTL) applications, **NASA's Black Marble nighttime lights product suite (VNP46/VJ146).** Distributed in Level 3 format, NASA's Black Marble nighttime lights products are available **from January 2012-present with data from the Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB), aboard the Suomi-NPP and NOAA-20 satellites, at 15 arc second spatial resolution** via NASA's Level 1 and Atmosphere Archive and Distribution System Distributed Active Archive Center (**LAADS-DAAC**), Amazon Web Services (**AWS**), and Google Earth Engine (**GEE**).

Figure 1 The image for the continental United States of NASA's Black Marble 2016 annual composite.

Overview of the Algorithm

The NASA Black Marble algorithm produces daily cloud-free nighttime radiances that have been corrected for atmospheric, terrain, lunar BRDF, and straylight effects. Key algorithm enhancements include: (1) lunar irradiance modeling to resolve non-linear changes in phase and libration; (2) vector radiative transfer and lunar bidirectional surface anisotropic reflectance modeling to correct for atmospheric and bidirectional reflectance distribution function (BRDF) effects; (3) geometric-optical and canopy radiative transfer modeling to account for seasonal variations in NTL; and (4) temporal gap-filling to reduce persistent data gaps.

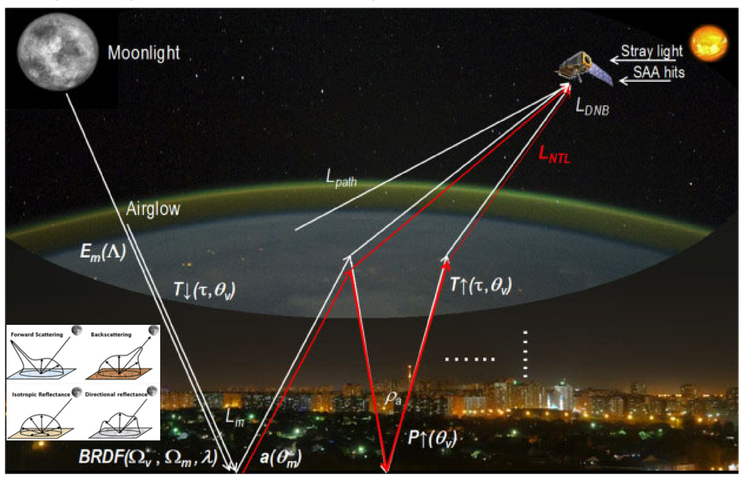


Figure 2 Overview of NASA's Black Marble retrieval strategy. During the ~50% portion of the lunar cycle when moonlight is present at the time of satellite observation, the surface upward radiance from artificial light emissions, L_{NTL} [units of nWatts·cm^{-2}·sr^{-1}], can be extracted from at-sensor nighttime radiance at TOA (L_{DNB}). L_{path} is the nighttime path radiance, $a(\theta_m)$ is the VIIRS-derived actual surface albedo. The atmospheric backscatter is given by ρ_a. $T_{\downarrow}(\tau,\theta_v)$ and $T_{\uparrow}(\tau,\theta_v)$ are the total transmittances along the lunar-ground and ground-sensor paths (respectively). $P_{\uparrow}(\theta_v)$ is the probability of the upward transmission of NTL emissions through the urban vegetation canopy.

Black Marble Product Suite

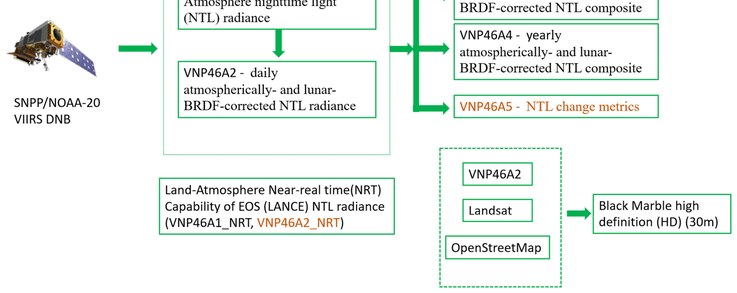


Figure 3 NASA's Black Marble Product Suite. Collection 2 reprocessing started from April 2023. VNP46A5 and VNP46A2_NRT are under development.

Safety, Resilience, and Sustainability

Hurricane Ian, 2022: Impact on Florida's energy sector

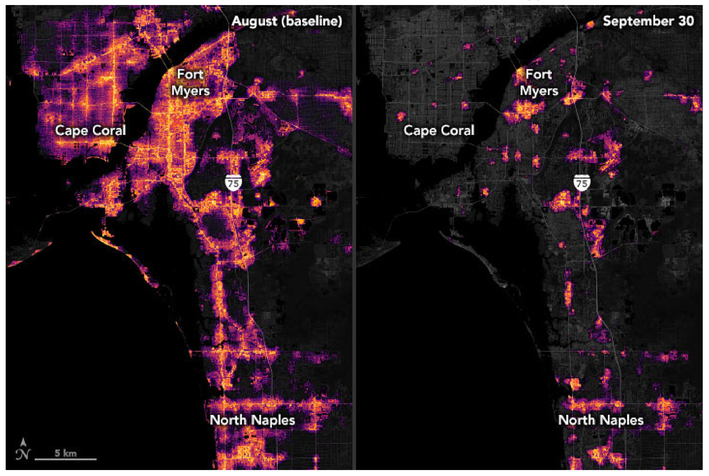


Figure 4 Power outage after Hurricane Ian over the metropolitan areas of Fort Myers.

Earthquake Türkiye, 2023

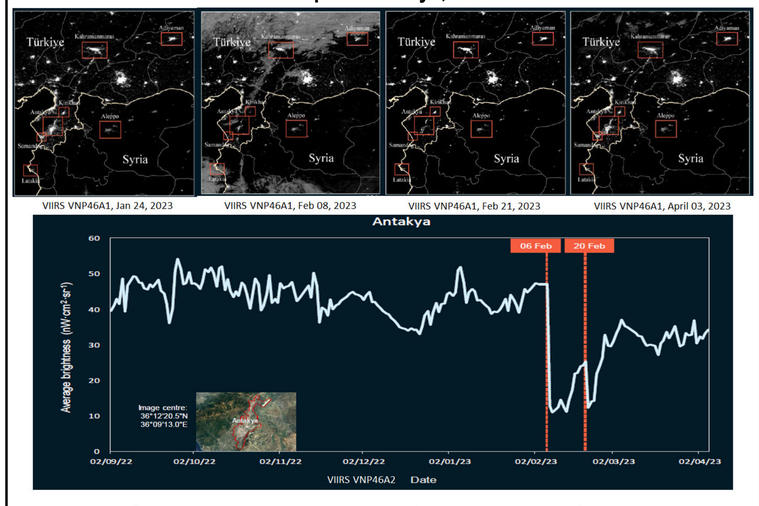


Figure 5 The power outage and recovery after the Earthquake using Black Marble products released by United Nations Satellite Centre (UNOSAT)

SNPP and NOAA-20 DNB Intercomparison

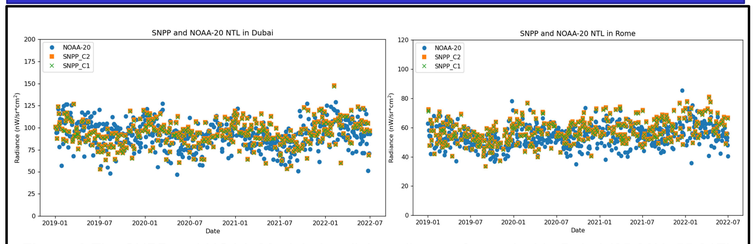
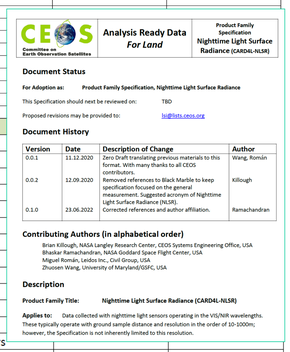


Figure 6 The SNPP and NOAA-20 nighttime light radiance of one pixel in Dubai (25.06N, 55.21E) and Rome (41.88N, 12.57E). The mean radiance of C1 and C2 SNPP and NOAA-20 in Dubai are 93.01, 93.88 and 92.05 nWcm^{-2}sr^{-1} respectively. The mean radiance of C1 and C2 SNPP and NOAA-20 in Rome (LED light) are 57.53, 58.07 and 54.49 nWcm^{-2}sr^{-1} respectively. The reduction of NOAA-20 radiance in Rome is due to the impact of spectral response function.

Nighttime light ARD Product Family Specification

	Threshold	Target
1. General Metadata		
1.1 Traceability		
1.2 Metadata Machine Readability		
1.3 Data Collection Time		
1.4 Geographical Area		
1.5 Coordinate Reference System		
1.6 Map Projection		
1.7 Geometric Correction Methods		
1.8 Geometric Accuracy of the Data		
1.9 Instrument		
1.10 Spectral Bands		
1.11 Sensor Calibration		
1.12 Radiometric Accuracy		
1.13 Algorithms		
1.14 Auxiliary Data		
1.15 Processing Chain Provenance		
1.16 Data Access		
1.17 Overall Data Quality		
2. Per-Pixel Metadata		
2.1 Metadata Machine Readability		
2.2 No Data		
2.3 Incomplete Testing		
2.4 Saturation		
2.5 Cloud		
2.6 Cloud Shadow		
2.7 Land/Water Mask		
2.8 Snow/Ice Mask		
2.9 Terrain Shadow Mask		
2.10 Terrain Occlusion		
2.11 Lunar and Viewing Geometry		
2.12 Terrain Illumination Correction		
2.13 Aerosol Optical Depth Parameters		
2.14 Moon Illumination Fraction		
2.15 Brightness Temperature		
2.16 Solar Zenith Angle		
3. Radiometric and Atmospheric Corrections		
3.1 Measurement		
3.2 Measurement Uncertainty		
3.3 Measurement Normalisation		
3.4 Atmospheric Corrections		
3.5 Lunar Radiance Corrections		
3.6 Stray Light Corrections		
4. Geometric Corrections		
4.1 Geometric Correction		



CEOS Committee on Earth Observation Satellites — Analysis Ready Data *For Land* — Product Family Specification: Nighttime Light Surface Radiance (CARD4L-NLSR)

Document Status

For Adoption as: Product Family Specification, Nighttime Light Surface Radiance

This Specification should next be reviewed on: TBD

Proposed revisions may be provided to: lsi@lists.ceos.org

Document History

Version	Date	Description of Change	Author
0.0.1	11.12.2020	Zero-Draft translating previous materials to this format. With many thanks to all CEOS contributors.	Wang, Román
0.0.2	12.09.2020	Removed references to Black Marble to keep specification focused on the general measurement. Suggested acronym of Nighttime Light Surface Radiance (NLSR).	Killough
0.1.0	23.06.2022	Corrected references and author affiliation.	Ramachandran

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Description

Product Family Title: Nighttime Light Surface Radiance (CARD4L-NLSR)

Applies to: Data collected with nighttime light sensors operating in the VIS/NIR wavelengths. These typically operate with ground sample distance and resolution in the order of 10-1000m; however, the Specification is not inherently limited to this resolution.

- Summary Nighttime Light Surface Radiance Self-Assessment Table (left).
- Black Marble Nighttime Lights product suite is a prime example that both serves and meets the requirements of this ARD specification.

References

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Acknowledgements

Support provided by NASA's Terra/Aqua/Suomi-NPP/NOAA-20 and Remote Sensing Theory for Earth Science Programs under NASA Grants 80NSSC22K0199 and 80NSSC20K1748.