NASA's New VIIRS Level 3 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).** 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 satellite, at 500m spatial resolution.**
The current Collection V1 VNP46 product suite includes the daily at-sensor top of atmosphere (TOA) nighttime radiance product (VNP46A1), and the daily moonlight-adjusted nighttime lights (NTL) product (VNP46A2).

Figure 1. The image for the continental United States of Black Marble 2016 annual composite generated using the NASA VIIRS DNB algorithm.

The NASA Black Marble Standard product suite (VNP46) is being processed on a daily basis within 3-5 hours after acquisition at the spatial resolution. **This enables both Near-Real Time (NRT) uses and long-term monitoring applications.** It is expected that the standard Black Marble product suite (i.e., Level 3 daily and multi-date formats) will be routinely available from the NASA LAADS DAAC by the end of 2018.

The Black Marble product suite (VNP46) will be made available both retrospectively, via NASA's Level 1 and Atmosphere Archive and Distribution System Distributed Active Archive Center (**LAADS-DAAC**), and in forward Near Real-Time (NRT) data streams, via NASA's Land, Atmosphere Near Real-time Capability for EOS (**LANCE**). The NRT data are mainly used in response to disasters and other management applications which require low latency data access.

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Overview of the Algorithm

The NASA Black Marble algorithm produces cloud-free nighttime radiances that have been corrected for atmospheric, terrain, lunar BRDF, thermal, and straylight effects. The corrected product, resulting in a superior retrieval of nighttime lights at short time scales and a reduction in background noise, enables quantitative detection and analyses of daily, seasonal, and annual variations. 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.

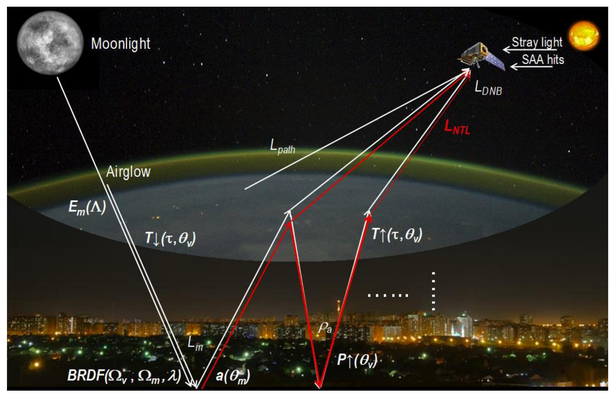

Figure 2 Overview of NASA's Black Marble retrieval strategy. During the ~50% portion of the lunar cycle when moonlight is present at the time of satellite observation, the surface upward radiance from artificial light emissions, L_{NTL} [units of nWatts·cm^{-2}·sr^{-1}], can be extracted from at-sensor 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.

Synergistic uses of NASA Products:
Black Marble + ECOSTRESS Surface Temperature Product

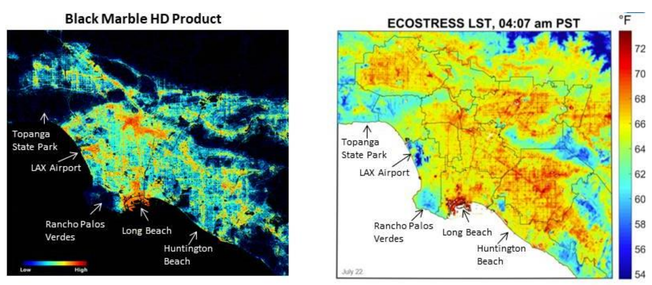

Figure 3 (Left) NASA Black Marble High Definition (HD) product provided night-time light map in Los Angeles, CA. High-light areas are shown in red, while low-light areas in black blue. (Right) ECOSTRESS captured surface temperature variations in Los Angeles, CA in the early morning hours of July 22. Hot areas are shown in red, warm areas in orange and yellow, and cooler areas in blue.
ECOSTRESS Image Source: **https://www.jpl.nasa.gov/news/news.php?feature=7238**

NASA Black Marble high definition (HD) product is being developed at 30m spatial resolution. **The patterns of spatial distribution of ECOSTRESS 'hot' areas look similar to the ones of Black Marble HD features across Los Angeles, CA.**

Applications

Hurricane Florence 2018: Pre-Event and Post-Event Assessment of North Carolina's Energy Sector using NASA's Black Marble Product Suite

On September 14, 2018, widespread power failures were reported across the state of North Carolina. NASA's Disasters program employed one of its core capabilities, NASA's Black Marble product suite, to enable immediate access to data documenting disruptions in energy infrastructure and utility services. The pre-event and post-event images in North Carolina are based on the composite Black Marble images. The fine resolution images show artificial lights at night prior to and after the arrival of Hurricane Florence. The Black Marble Level 3 and 30 m High Definition (HD) data are continuously being produced and delivered to FEMA end-users for the latest day available.

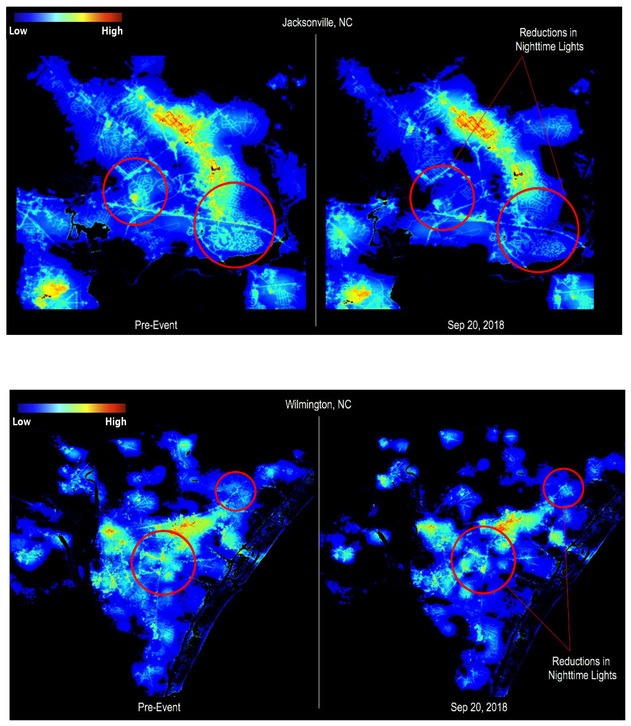

Figure 4 Suomi-NPP VIIRS Black Marble nighttime data showing pre and post event imagery from Jacksonville and Wilmington in North Carolina, for Hurricane Florence in September, 2018.

References

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