

GROUP ON
EARTH OBSERVATIONS

Introduction to NASA's "Black Marble" Night Lights Data

December 3, 2020

Course Structure and Details

- 1 Session: December 3, 2020
- Webinar recording, PowerPoint presentation, and homework assignment can be found at: <https://appliedsciences.nasa.gov/join-mission/training/english/introduction-nasas-black-marble-night-lights-data>
- Q&A: 20 minutes following the lecture
- Certificate of Completion
 - Attend webinar
 - Complete assignment accessed from the ARSET Black Marble webinar website (above)
 - You will receive a certificate approximately 1 month after completion of the course.



Course Instructors

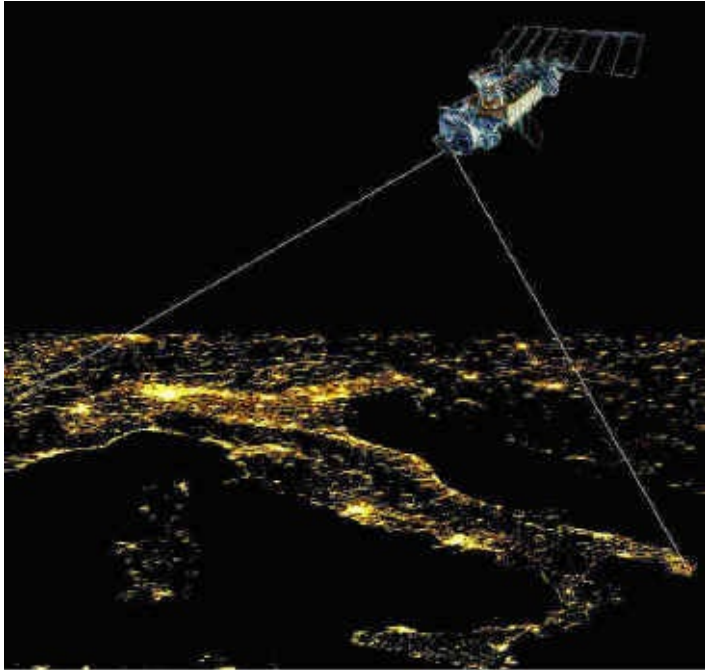
- Eleanor C. Stokes, Ph.D.
 - Science PI of NASA's Black Marble Product Suite
 - Scientist at USRA's Earth from Space Institute

- Ranjay Shrestha, Ph.D.
 - Scientific Programmer/Analyst
at NASA Goddard Space Flight Center



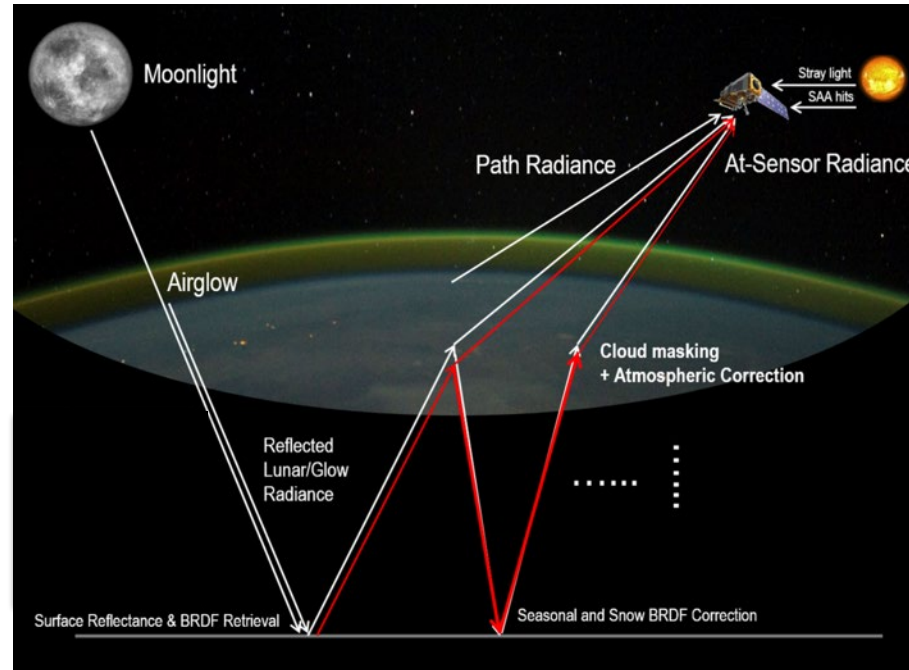
Course Outline

Part 1 (30 min)



Basics and Background of Nighttime Remote Sensing

Part 2 (15 min)



Black Marble Processing & Data Analysis

Part 3 (15 min)



Science and Applications



Learning Objectives

By the end of this presentation, you will understand:

Basics and Background:

- The light sources that are captured in Nighttime Lights (NTL) data.
- Differences between existing nighttime lights products.
- What is corrected and not corrected for in the Black Marble algorithm.

Acquiring and Using the Data:

- How to download Black Marble images via the Level-1 and Atmosphere Archive & Distribution System (LAADS).
- What are the different bands in the Black Marble Product?
- How to consider Quality Assessment indicators.
- How to process Black Marble data to get a time series.

Applying the Data:

- How night lights data is being applied to
 - urban studies
 - disaster monitoring
 - COVID-19



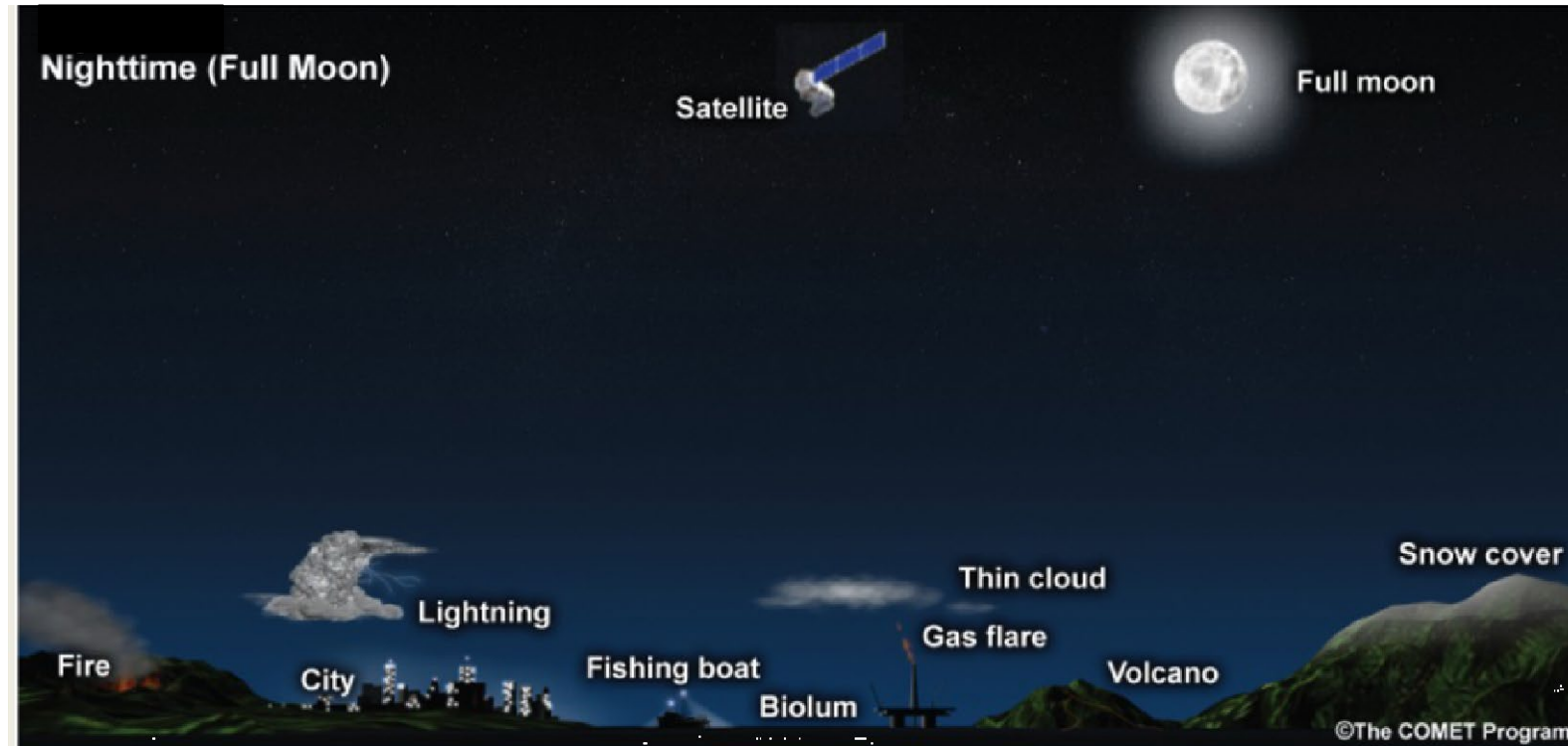


Part 1: Basics and Background of Nighttime Remote Sensing

What can we study with nighttime remote sensing?

With moonlight:

- The reflectance of snow cover, smoke, airborne dust, sea ice, and land surface features are visible
- Imaging cloud cover to support short-term weather prediction is the primary purpose of nighttime sensors.



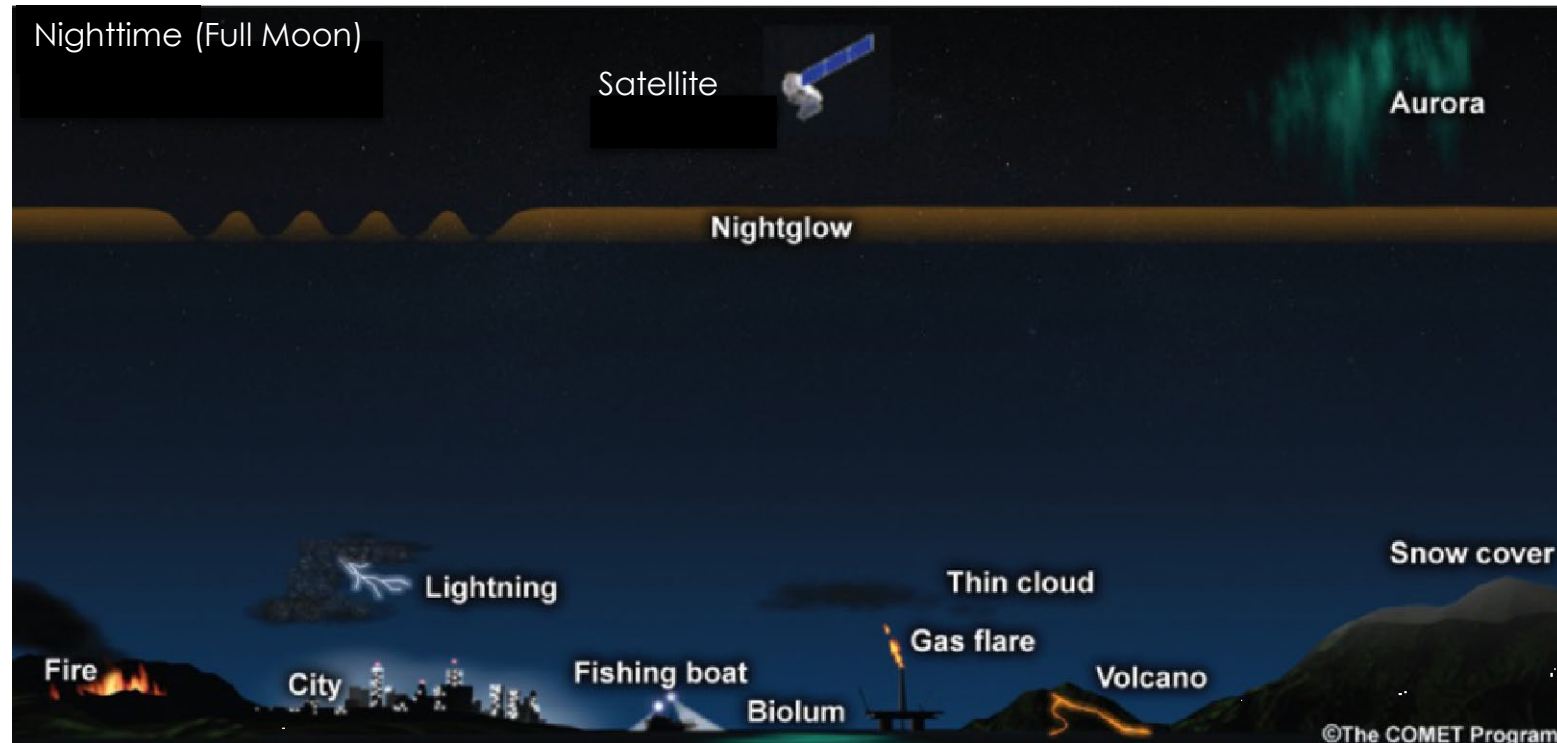
Miller et. al, 2013



What can we study with nighttime remote sensing?

Without moonlight:

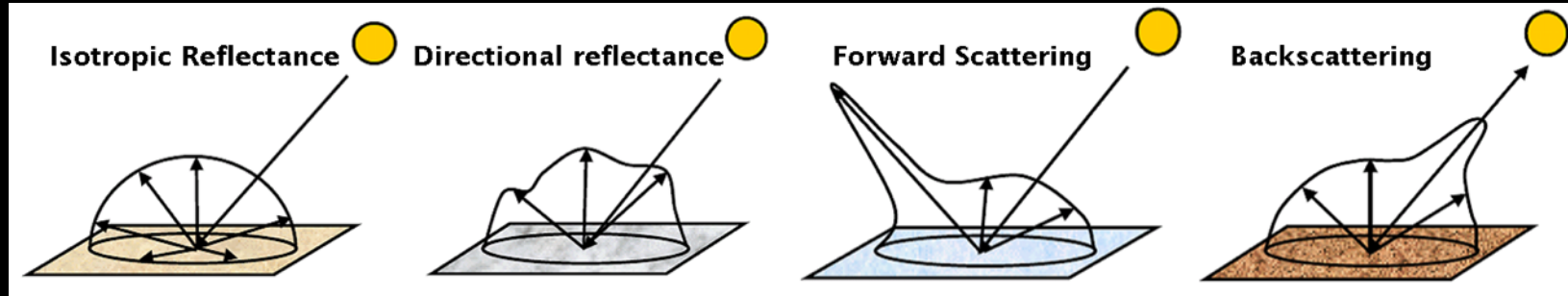
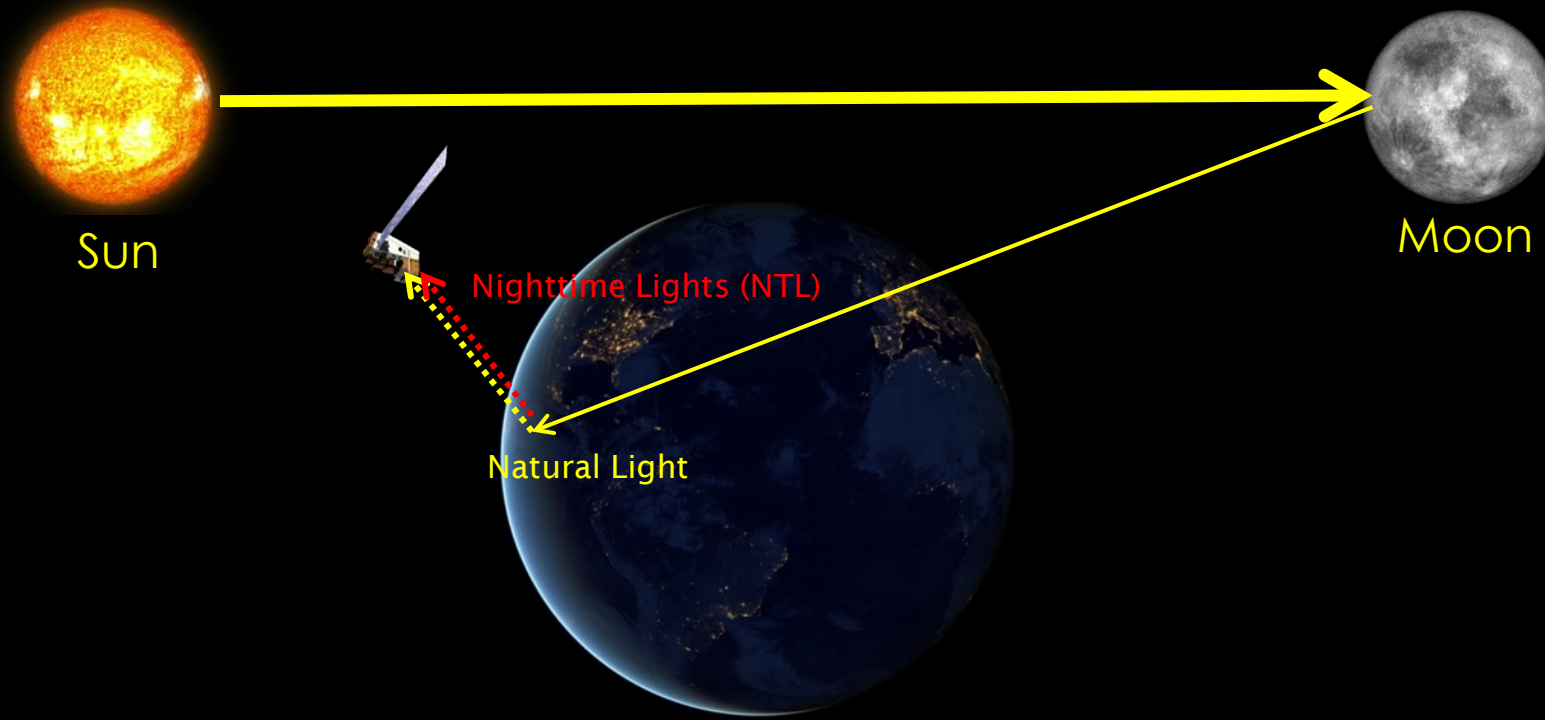
- Artificial lights like street and building lighting
- Fishing boats
- Gas flares
- Fires
- Aurora
- Bioluminescence
- Nightglow from the atmosphere



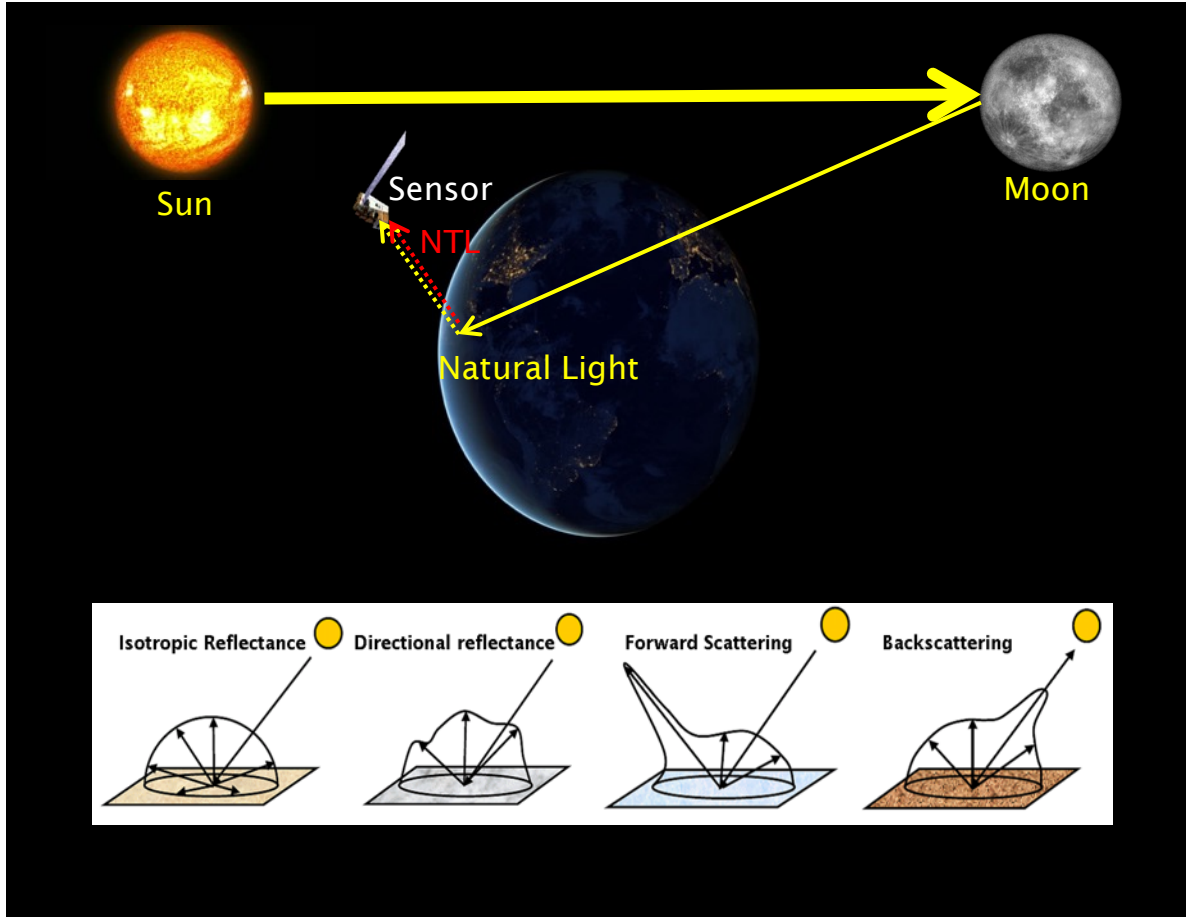
Miller et. al, 2013



Principles of Nighttime Remote Sensing



Principles of Nighttime Remote Sensing

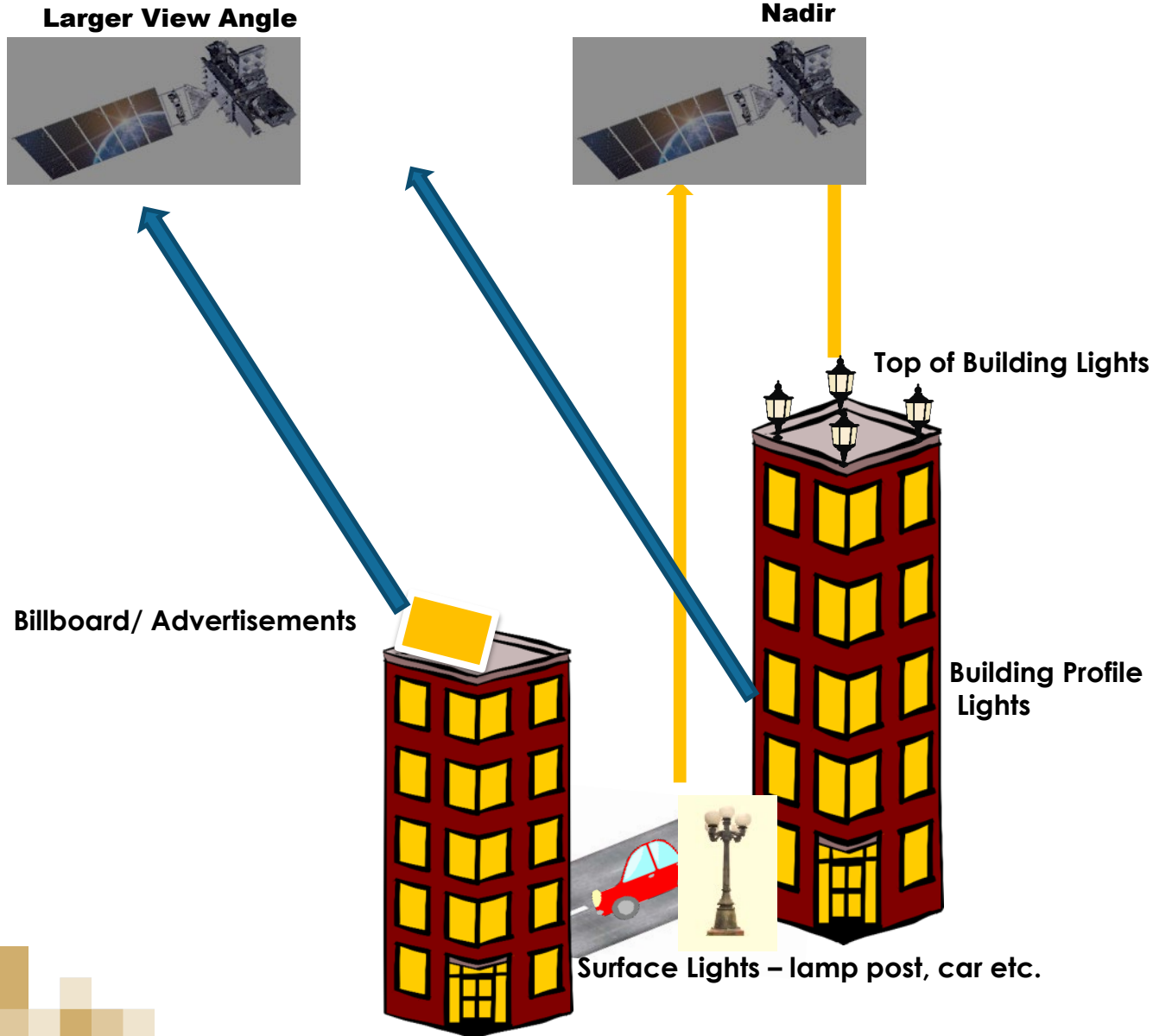


Unlike in daytime remote sensing:

- There are multiple light sources.
- Observations include moonlight, light directly emitted by a source (e.g., buildings and transport), and light scattered by the ground.
- Snow (both under moon-illuminated and moon-free conditions) can also increase the signal during winter months.
- Land features (such as buildings and trees) can also block the light source during different time periods.



Principles of Nighttime Remote Sensing



- Light sources have different angular emission and reflection profiles.
- Different satellite viewing angles may change light sources captured.
- Angular differences are more prominent in city centers (downtown areas) with tall buildings.



Nighttime Light Sensor/Products

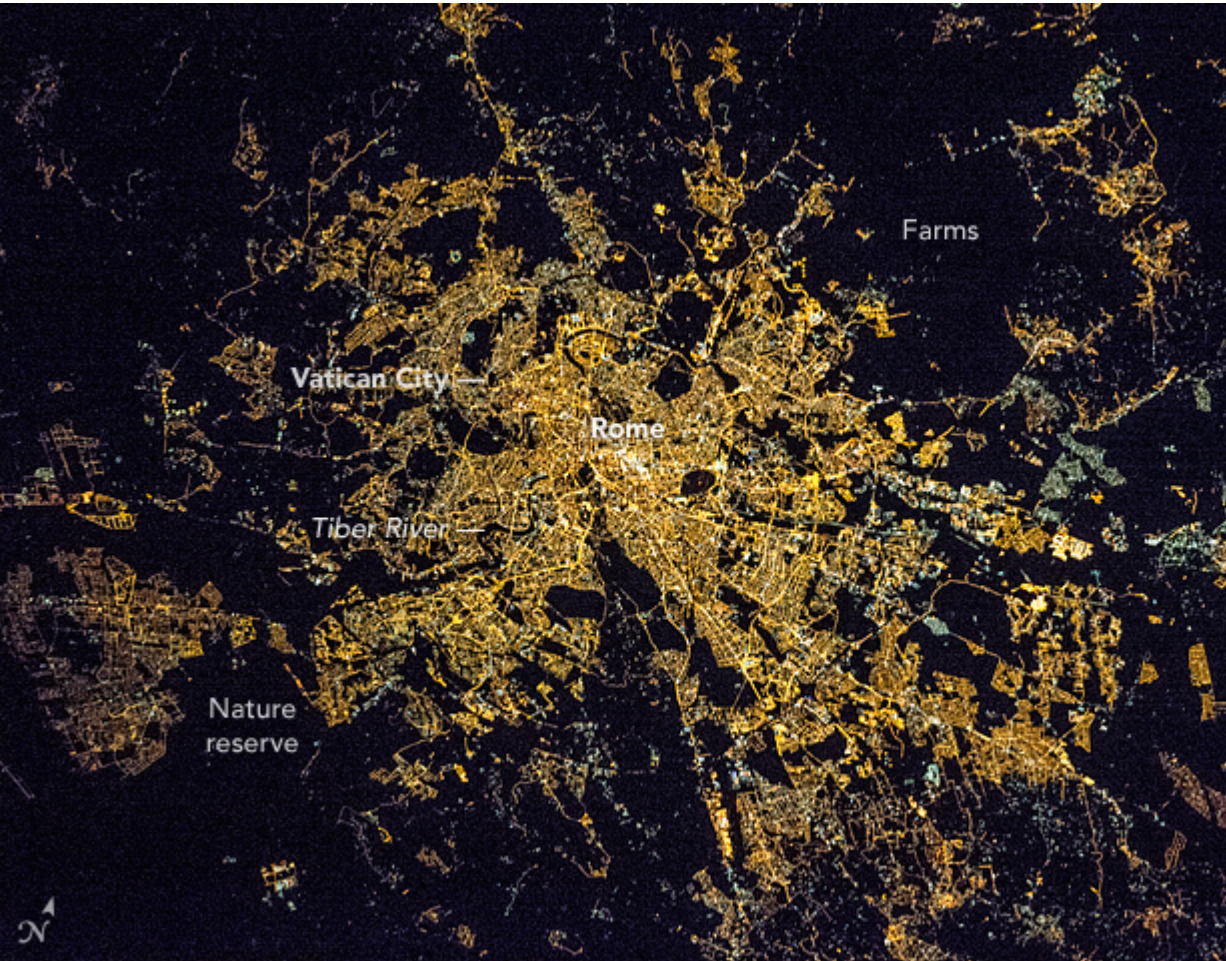
International Space Station (ISS) Images

- Astronaut photographs of the Earth at night.
- Provides imagery information in 3 visible spectral bands (R,G,B).
- Quality greatly improved (10m-resolution) with the installation of the NightPod instrument in 2012.
- Images are not scientific data.
 - Lack of georeferencing makes it difficult to locate a specific city among millions of images.
 - No consistency across space or time.
- Images are available at NASA's "The Gateway to Astronaut Photography of Earth" (<https://eol.jsc.nasa.gov/>).
- "Atlas of astronaut photos of Earth at night" developed as an open directory with geotagged images of cities at night (<http://www.citiesatnight.org/>).



Nighttime Light Sensor/Products

International Space Station (ISS) Images



Rome at Night - Acquired on April 8, 2015, with a Nikon D4 digital camera, and is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center.
(nasa.gov/mission_pages/station/images)



Italy at Night - acquired on October 21, 2014, with a Nikon D4 digital camera, and is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center.
(nasa.gov/mission_pages/station/images)

Previous-Generation Nighttime Light Sensor/Product

Defense Meteorological Satellite/Operational Linescan System (DMSP/OLS)

- Longest running system of global nighttime light detection from satellites.
- The digital data stream for the collection of DMSP-OLS began in 1992 and continues to this day.
- Many studies have taken advantage of extensive historical data to monitor artificial lights from space and study relationships between human activity and socio-economic variables.

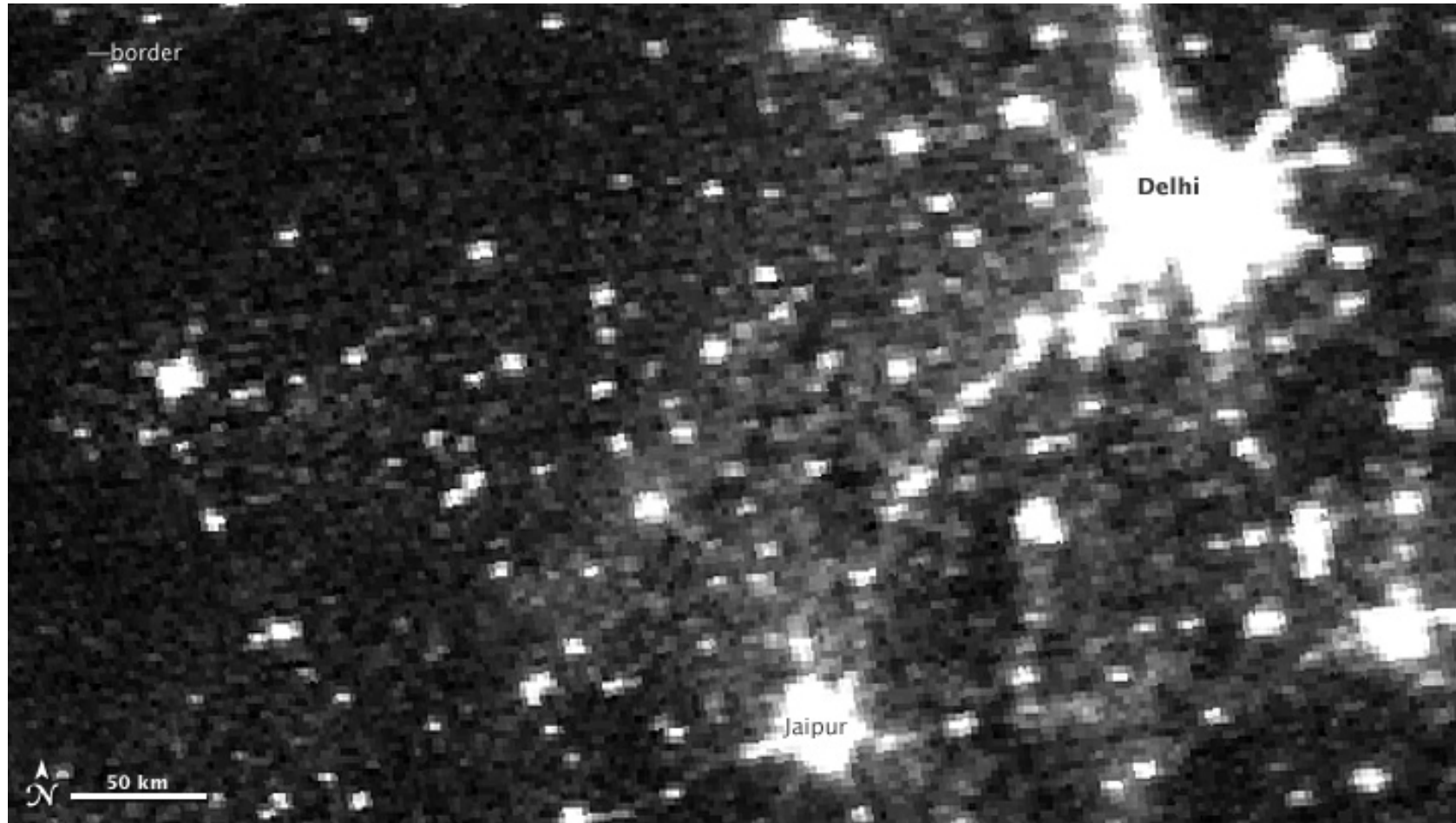


DMSP Satellite
Source: NOAA



Previous-Generation Nighttime Light Sensor/Product

DMSP/OLS



- Monthly product
- 2.7 km
- No on-board calibration
- 20:00 overpass
- Saturates in urban centers (6 bit)
- Available since 1992

City, Village, and Highway Lights Near Delhi, India - Acquired in November, 2012



Next-Generation Nighttime Light Sensor/Product

The Visible Infrared Imaging Radiometer Suite Day-Night Band (VIIRS DNB)

- One of the 5 instruments onboard the Suomi National Polar-orbiting Partnership (Suomi-NPP) and Joint Polar Satellite System (JPSS) satellite platform operational since 2012.
- Joint partnership between NASA and NOAA.
- Orbits the Earth in ~102 mins, providing global coverage at ~14 orbits per day at 824 km orbital altitude.
- Sun-synchronous satellite captures the observation near 01:30 local solar time.



Suomi-NPP Satellite
Source NASA



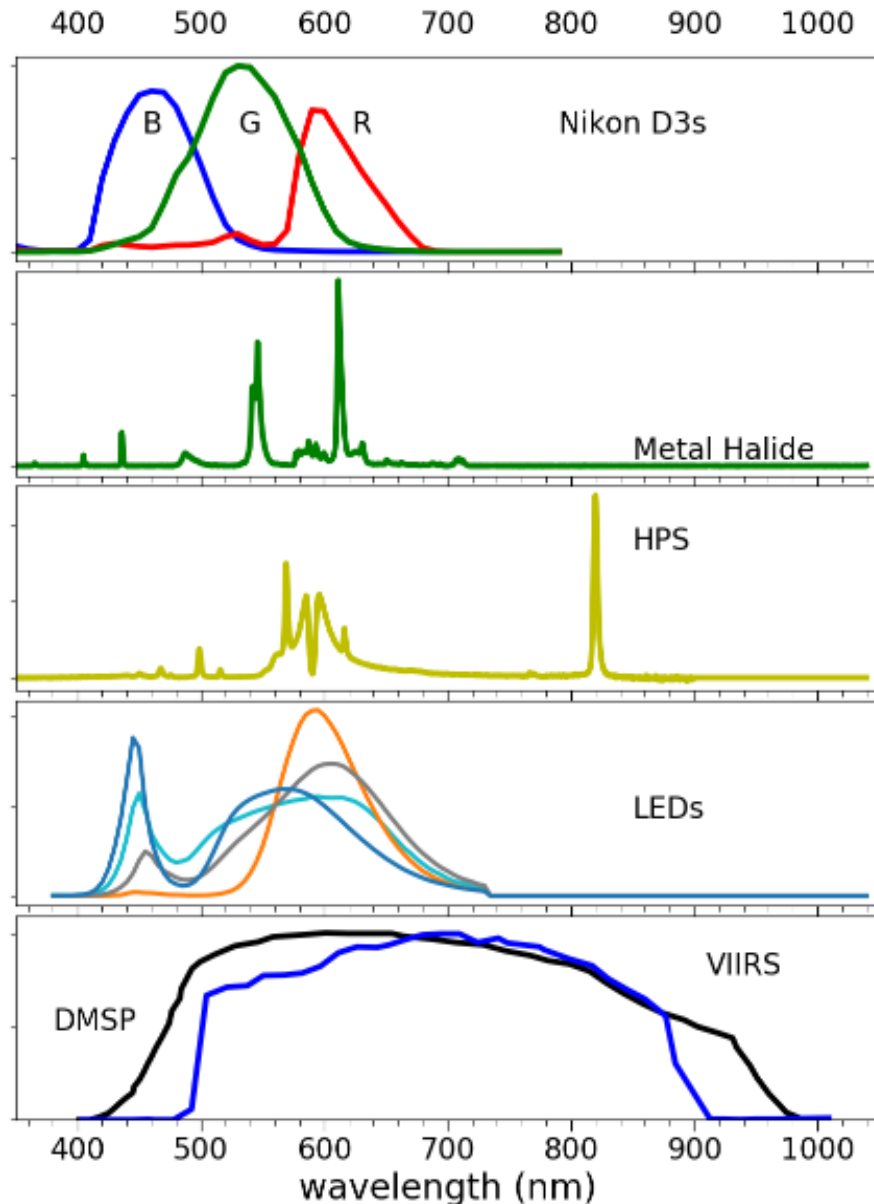
Nighttime Light Sensor/Products

Comparison DMSP/OLS and VIIRS DNB

Attribute	DMSP/OLS	VIIRS DNB
Orbital Details	Sun-synchronous, ~850 km	Sun-synchronous, 824 km
Nighttime Overpass Time	~1930 UTC	~0130 UTC
Swath Width	3000 km	3000 km
Spectral Passband Bandwidth	Panchromatic 500–900 nm	Panchromatic 500–900 nm
Spectral Passband Center	~600 nm	~700 nm
Horizontal Spatial Resolution	5 km (Nadir)/~7 km (Edge)	<0.770 km (Scan) <0.750 km (Track)
Minimum Detectable Signal	$4 \times 10^{-5} \text{ W} \cdot \text{m}^{-2} \cdot \text{sr}^{-1}$	$3 \times 10^{-5} \text{ W} \cdot \text{m}^{-2} \cdot \text{sr}^{-1}$
Noise Floor	$\sim 5 \times 10^{-6} \text{ W} \cdot \text{m}^{-2} \cdot \text{sr}^{-1}$	$\sim 5 \times 10^{-7} \text{ W} \cdot \text{m}^{-2} \cdot \text{sr}^{-1}$ (Nadir)
Radiometric Quantization	6 bit	13–14 bit
Radiometric Calibration	None	On-Board Solar Diffuser
Saturation, Stray Light Artifacts	Urban Cores, Substantial, Uncorrectable	None, Near-Terminator, Corrected



Nighttime Light Sensor/Products



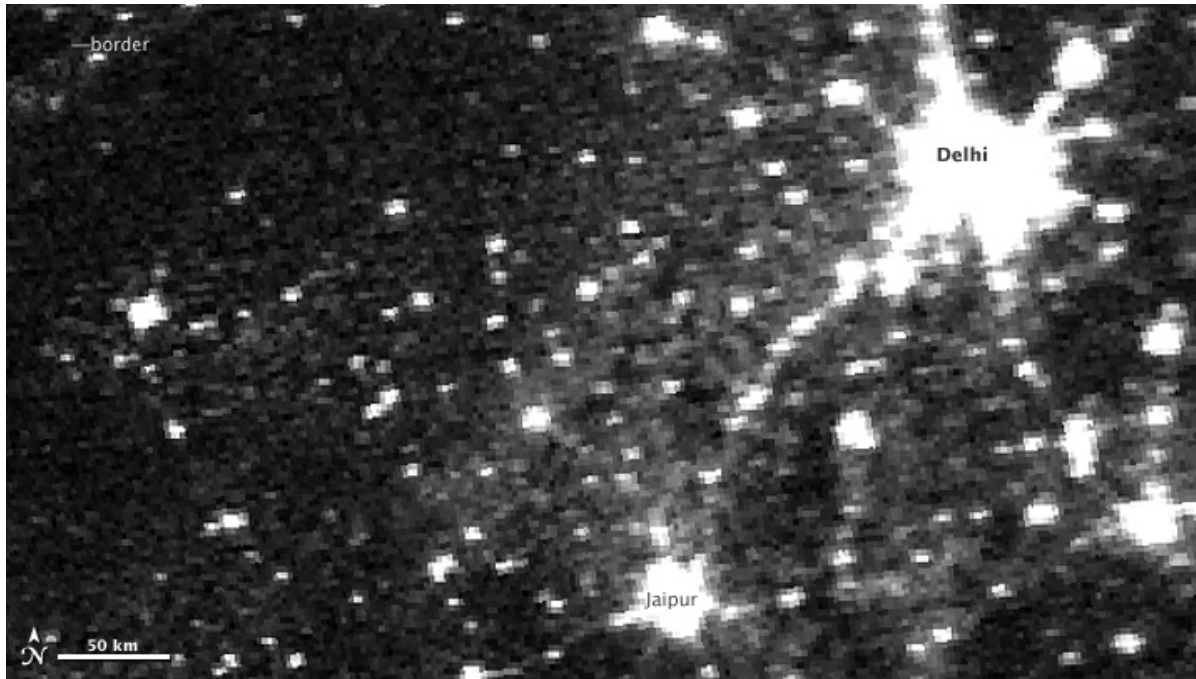
Spectral responses of the most popular sensors and light sources:

- Nikon D3s Cameras used by the astronauts at the ISS
- Metal Halide lamp, popular on architectural lights
- High pressure sodium (HPS) light, popular until 2014 on street lighting
- LEDs of 5000K (blue), 4000K (cyan), 2700K (grey), and PC-Amber (amber), popular on street lighting
- Representative spectral response of DMSP/OLS (black) and Suomi-NPP/VIIRS/DNB (blue)

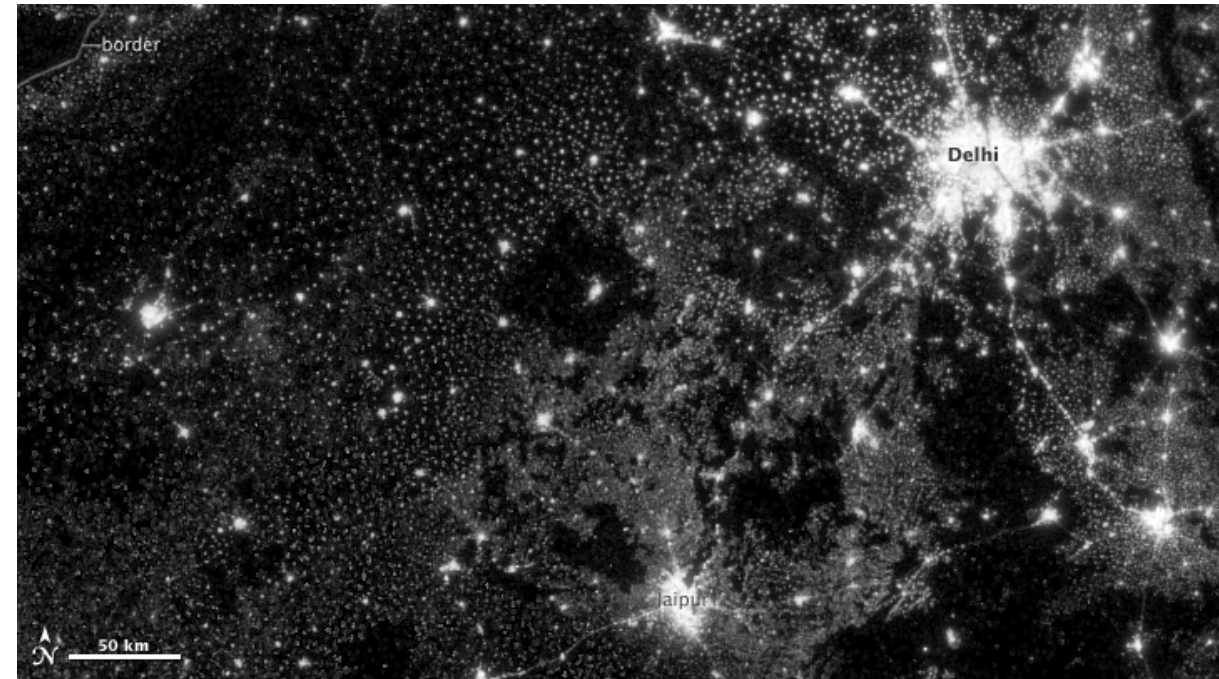


Nighttime Light Sensor/Products

DMSP/OLS



VIIRS DNB



City, Village, and Highway Lights Near Delhi, India - Acquired in November, 2012

- Monthly product
- 2.7 km
- No on-board calibration
- 20:00 overpass
- Saturates in urban centers (6 bit)
- Available since 1992

- Daily product
- 500 m
- On-board calibration
- 1:30 overpass
- Can measure both bright and very dim lights (14 bit)
- Available since 2012



NASA's Black Marble (VNP46) Data Product

Product Overview

- Data from VIIRS DNB aboard Suomi-NPP satellite (Collection V001)
- Level 3 product
- Available for the entire Suomi-NPP time series record (c. 2012 – YTD) through NASA's Level-1 and Atmosphere Archive and Distribution System (LAADS) for science research and long-term analysis
- Processed within 3-5 hours after acquisition through NASA's Land, Atmosphere Near real-time Capability for EOS (LANCER) system, for rapid response applications



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

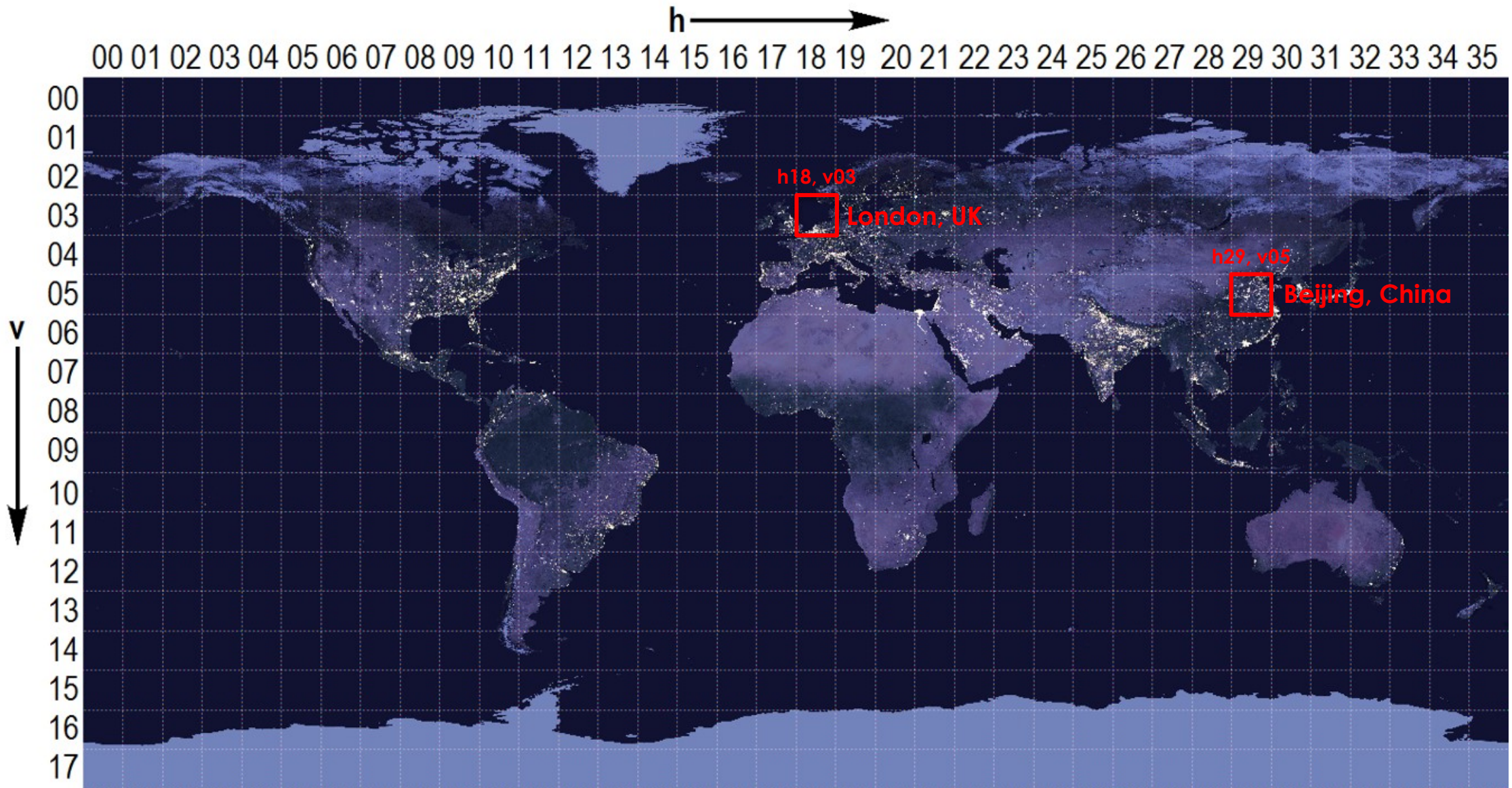


Comparison of NOAA (DMSP-heritage) VIIRS Nighttime Lights and NASA Black Marble - What is corrected for?

	NOAA VIIRS V1	NASA Black Marble V1
Frequency	Monthly and annual composites	Daily, monthly, and annual composites
Moonlight	Uses moon-free nights	Uses all nights and corrects lunar reflectance effects
Snow	Uncorrected for snow reflectance	Corrects for snow BRDF effects
Stray light	Filtered	Filtered
Ephemeral Lights	Filtered (for Annual Products)	Not filtered
Atmospheric effects	Not corrected	Corrected
Clouds	Cloud-free	Cloud-free

For more information about the algorithm, refer to Román, M.O., Wang, Z., Sun, Q., Kalb, V., Miller, S.D., Molthan, A., Schultz, L., Bell, J., Stokes, E.C., Pandey, B. and Seto, K.C., 2018. NASA's Black Marble nighttime lights product suite. *Remote Sensing of Environment*, 210, pp.113-143.





The Suomi-NPP VIIRS linear latitude/longitude (or geographic) grid consists of 460 non-overlapping land tiles which cover approximately $10^\circ \times 10^\circ$ regions. Examples presented in this webinar are enclosed in red boxes.

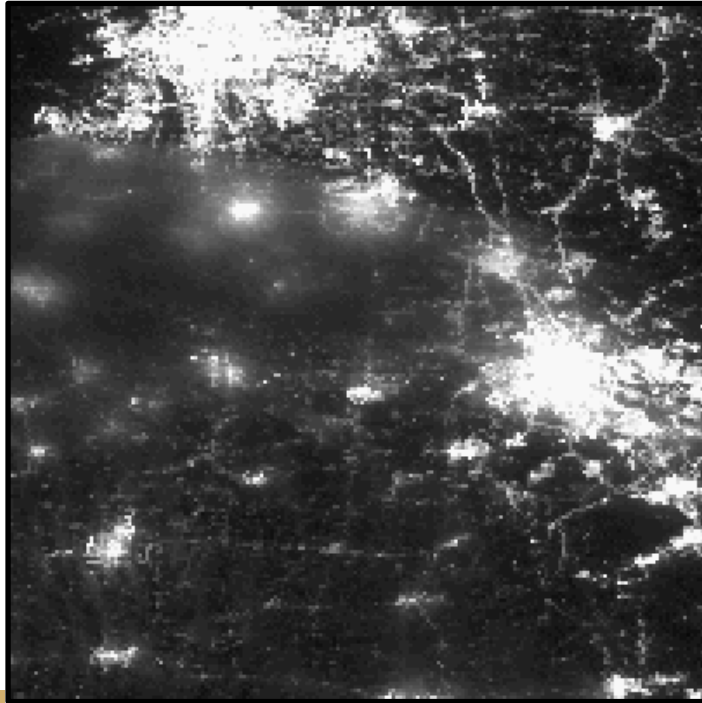
<https://blackmarble.gsfc.nasa.gov/tools/BlackMarbleTiles.zip>



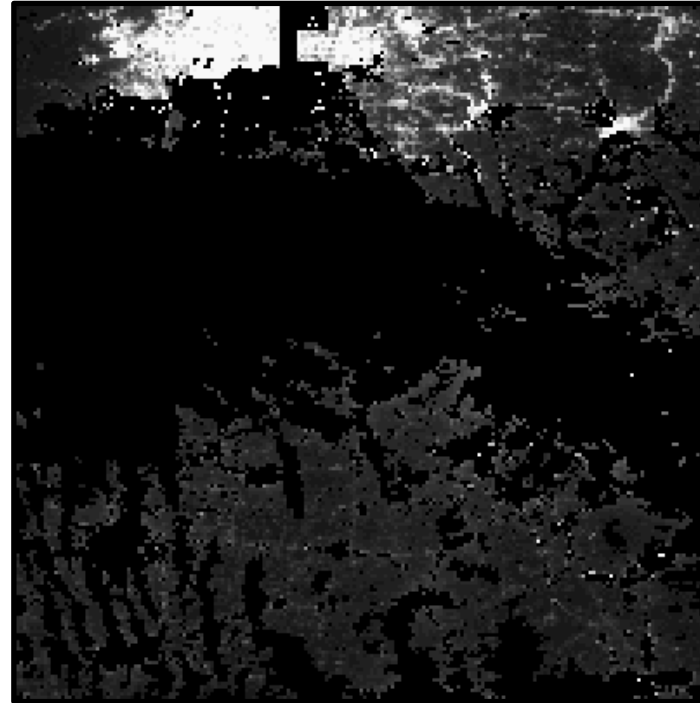
NASA's Black Marble Data Product

Location: Beijing, China
Tile: h29v05
DOY: 2020-063
Moon-Illuminated Fraction: 42.02%

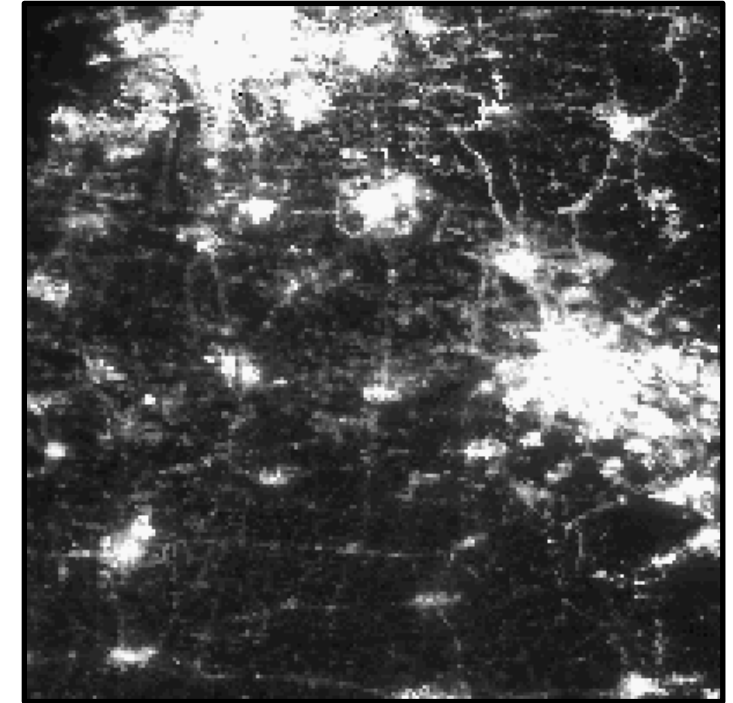
VNP46A1-TOA



VNP46A2-Daily



VNP46A2-GapFilled



NASA's Black Marble Data Product

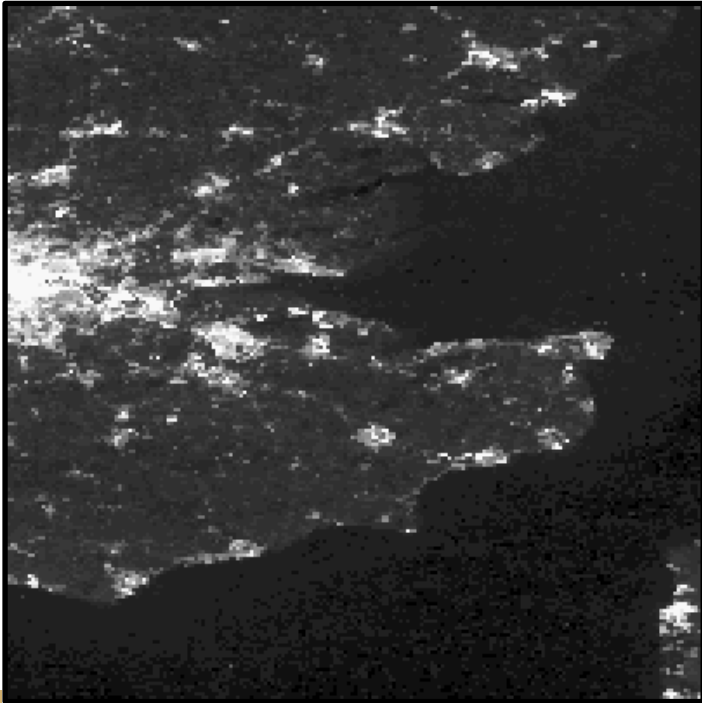
Location: London, United Kingdom

Tile: h18v03

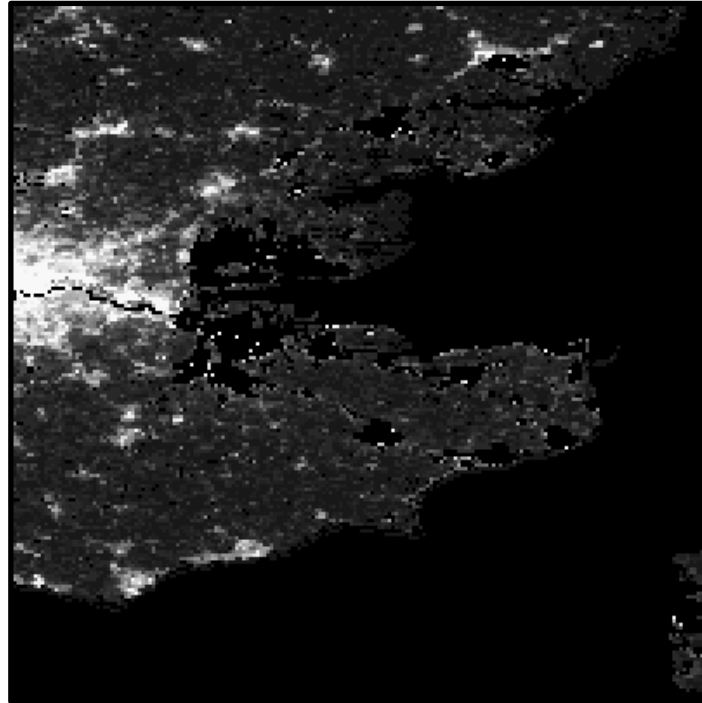
DOY: 2020-096

Moon-Illuminated Fraction: 57.91%

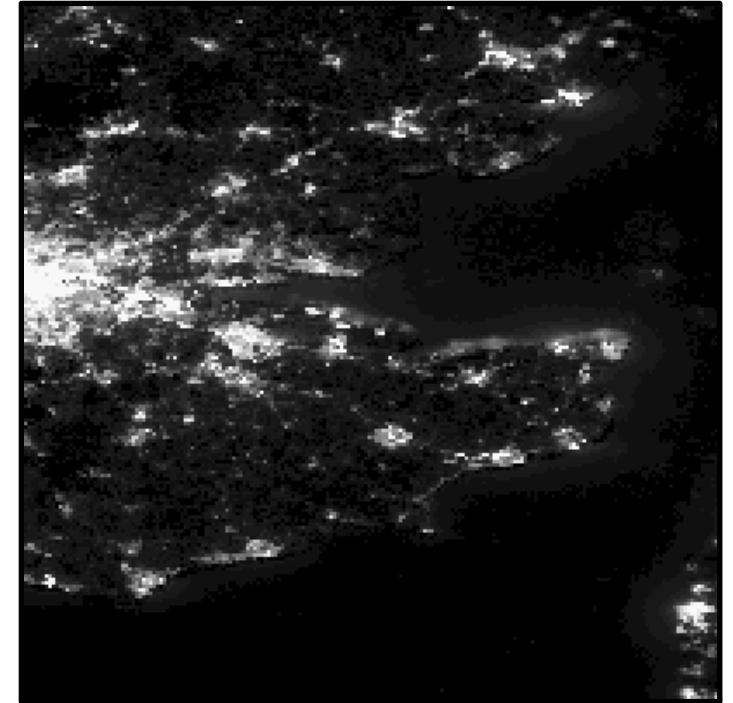
VNP46A1-TOA



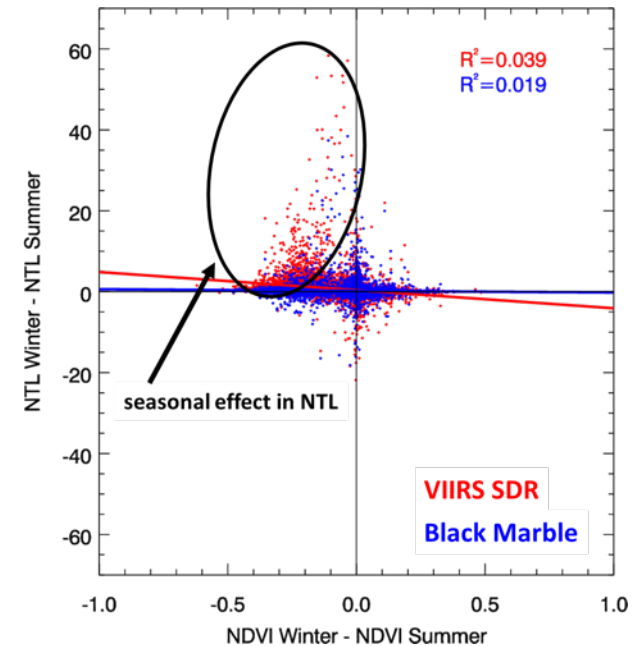
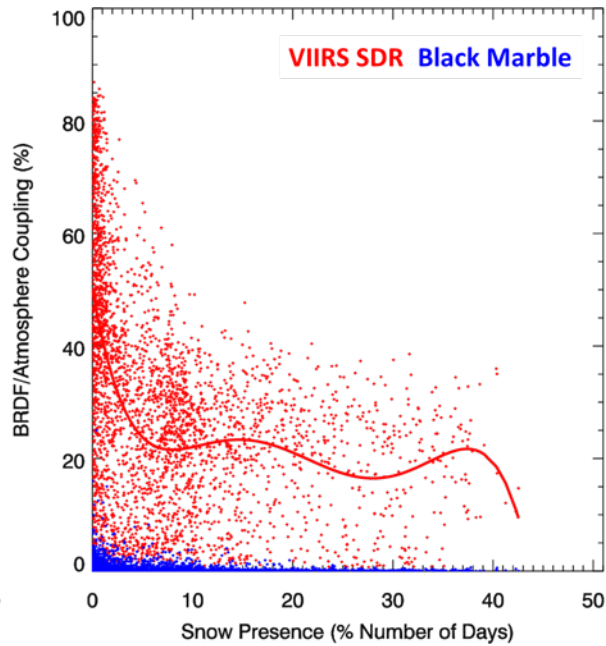
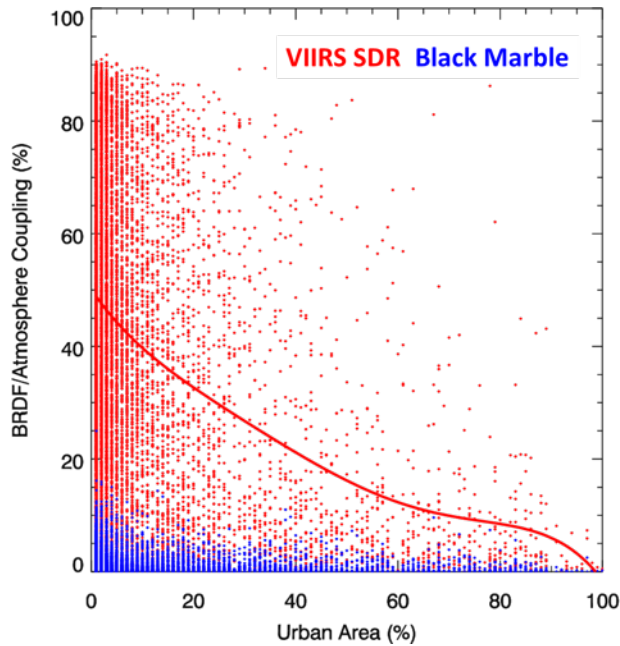
VNP46A2-Daily



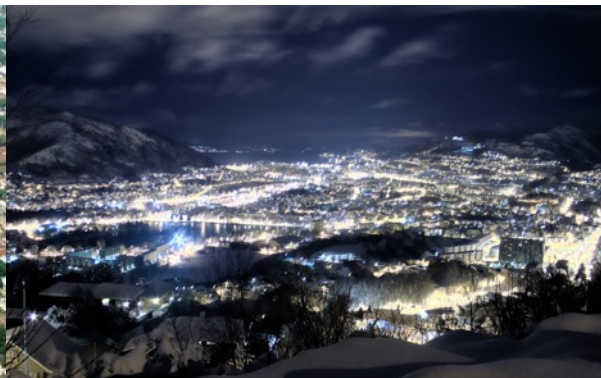
VNP46A2-GapFilled



Product Quality Assessment



Rural-Urban Gradient Test



Snow BRDF Test

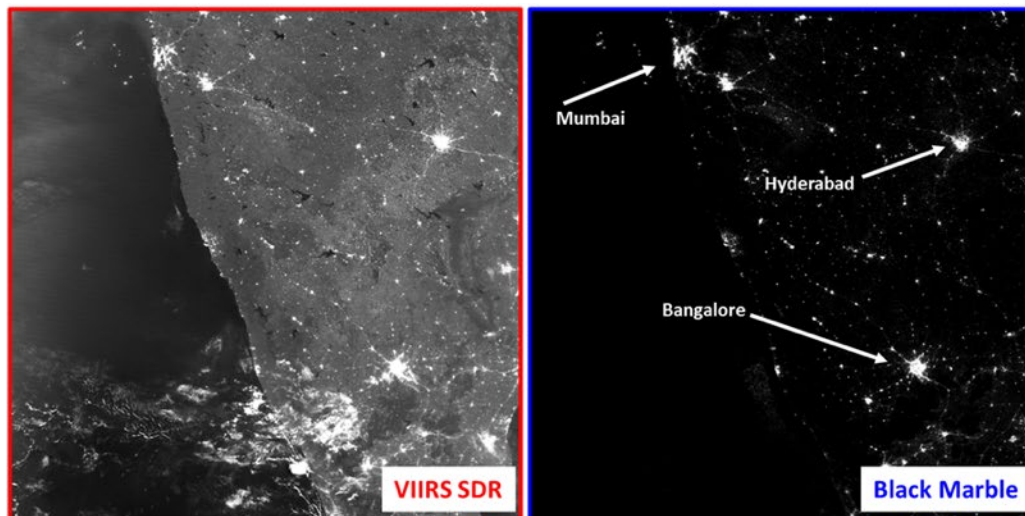


Vegetation Occlusion Test

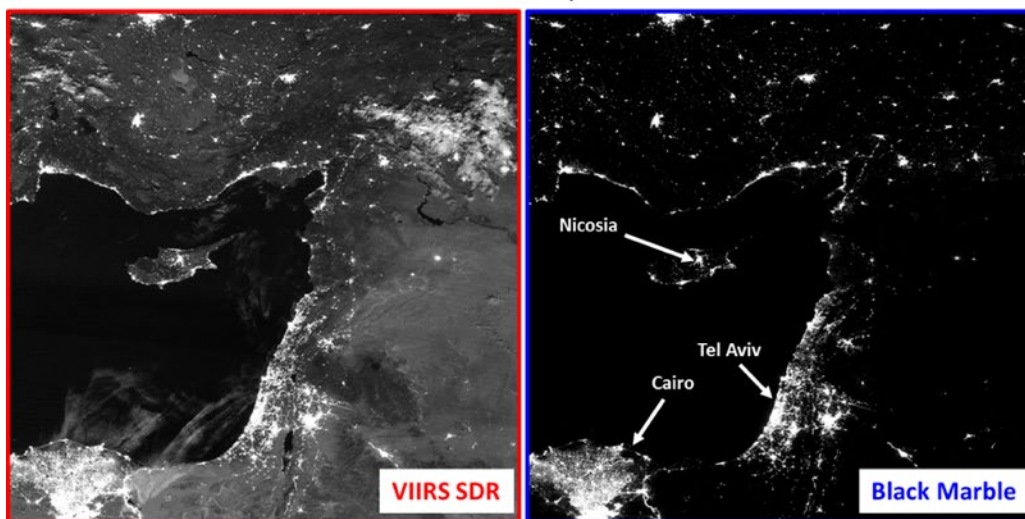
For more information, refer to Román, M.O., Wang, Z., Sun, Q., Kalb, V., Miller, S.D., Molthan, A., Schultz, L., Bell, J., Stokes, E.C., Pandey, B. and Seto, K.C., 2018. NASA's Black Marble nighttime lights product suite. *Remote Sensing of Environment*, 210, pp.113-143.



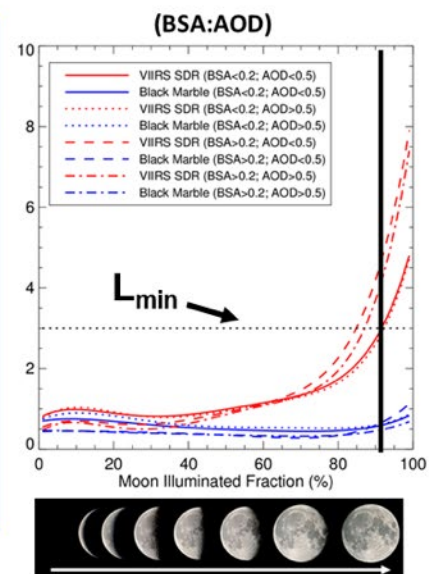
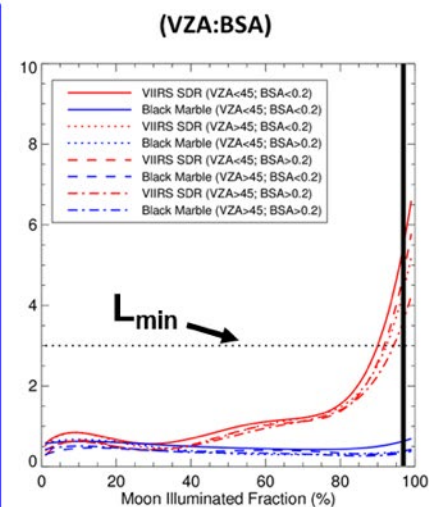
Product Quality Assessment



Western India - DOY 2013-323 ; Moon Fraction = 97%



Eastern Mediterranean Coast - DOY 2016-175 ; Moon Fraction = 92%



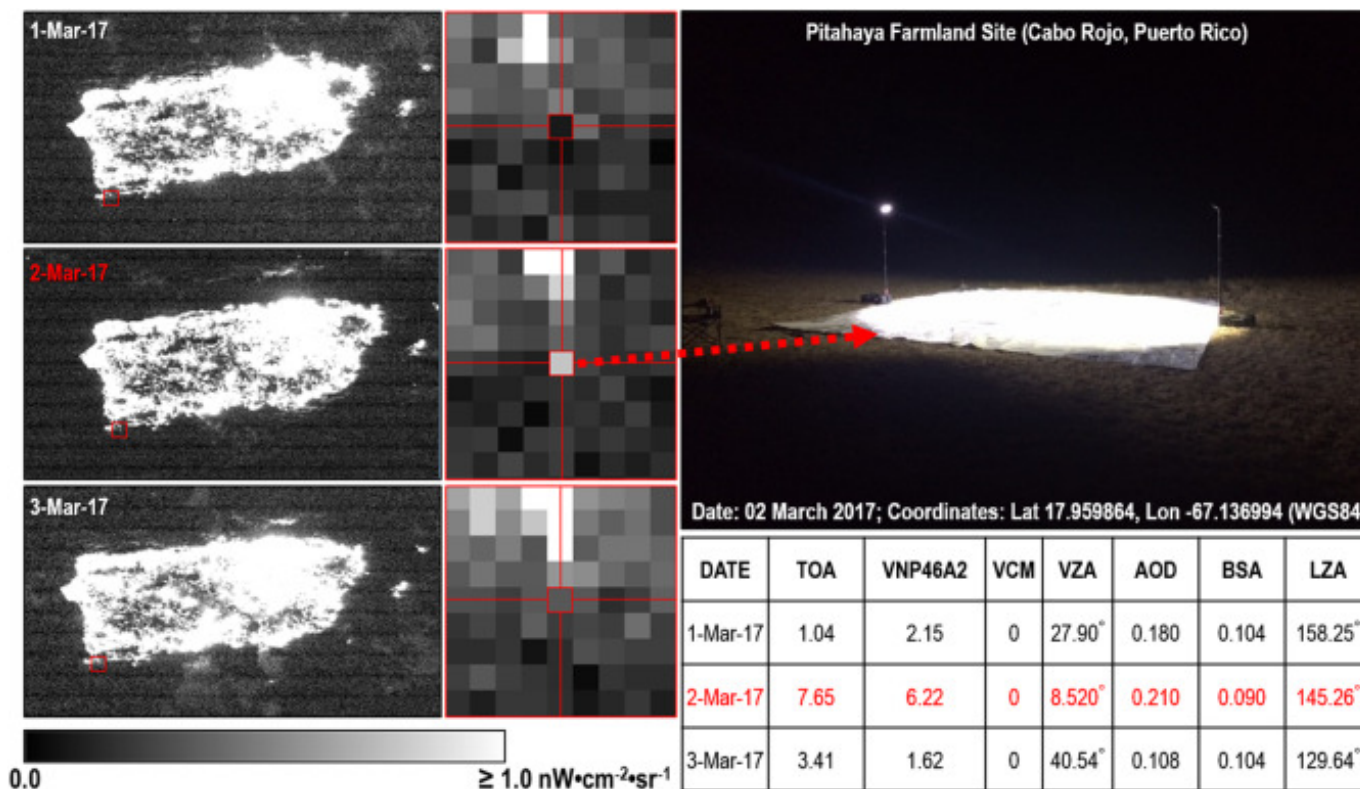
For more information, refer to Román, M.O., Wang, Z., Sun, Q., Kalb, V., Miller, S.D., Molthan, A., Schultz, L., Bell, J., Stokes, E.C., Pandey, B. and Seto, K.C., 2018. NASA's Black Marble nighttime lights product suite. *Remote Sensing of Environment*, 210, pp.113-143.



Product Validation

Field Experiments

- Conducted across multiple light pollution abatement zones in Puerto Rico
- Partnered with Puerto Rico's Working Group on Light Pollution (PRWGLP)
- A stable point source was reflected by a 30 m² Lambertian target to generate an in-band DNB radiance at sensor.



The NTL radiances at the Pitahaya Farmland site in Cabo Rojo, PR on 1st, 2nd and 3rd March 2017. The top-right image shows the setup of the stable point source. TOA and VNP46A2 values are in nW·cm⁻²·sr⁻¹. VCM = 0 represents cloud free overpasses. LZA is lunar zenith angle, and the values larger than 108° correspond to moonless nights.

For more information, refer to Román, M.O., Wang, Z., Sun, Q., Kalb, V., Miller, S.D., Molthan, A., Schultz, L., Bell, J., Stokes, E.C., Pandey, B. and Seto, K.C., 2018. NASA's Black Marble nighttime lights product suite. *Remote Sensing of Environment*, 210, pp.113-143.





Part 2: Black Marble Processing & Data Analysis

Where to Obtain the Black Marble Product

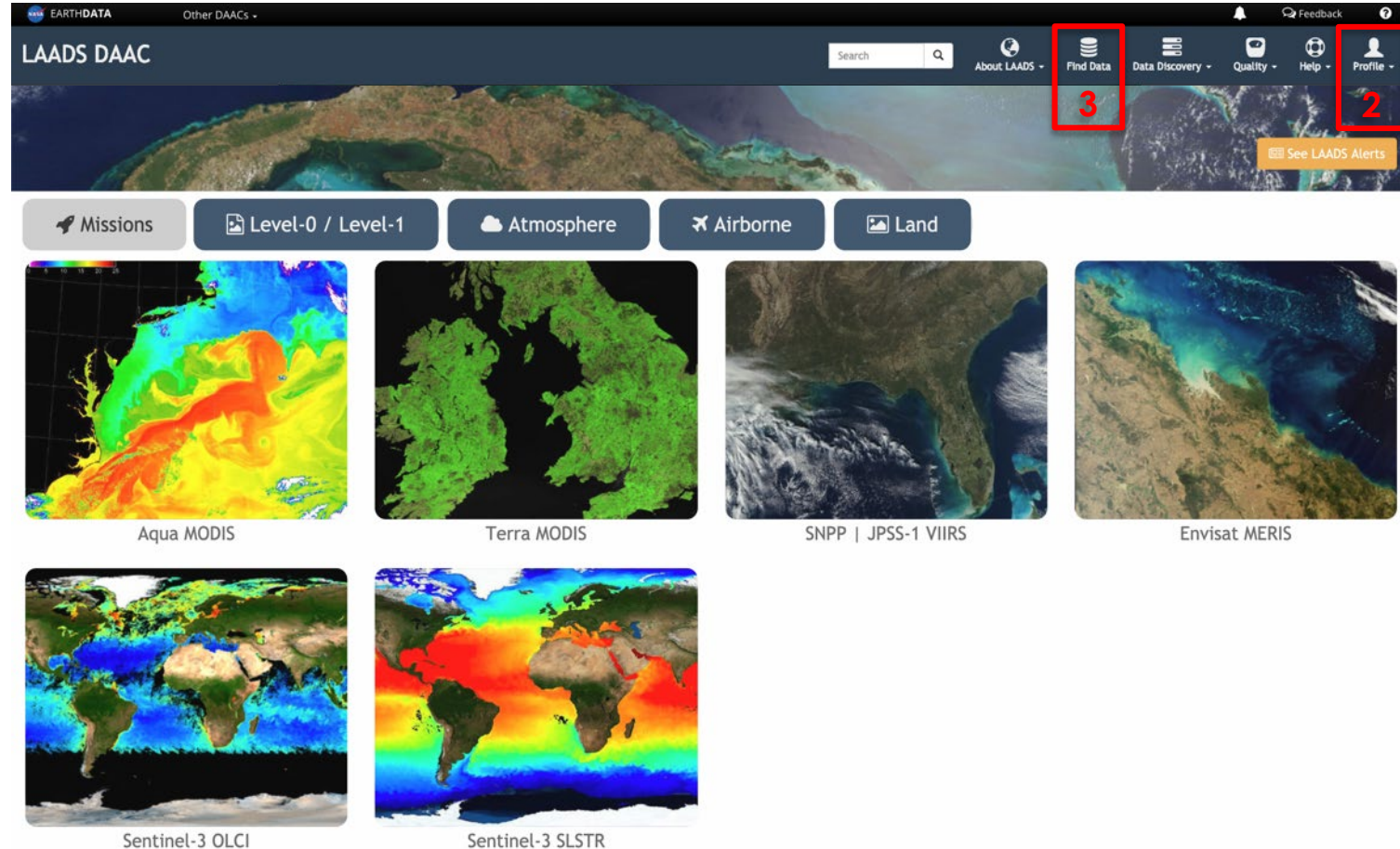
NASA's Level-1 Land and Atmosphere Archive and Distribution System Distributed Active Archive Center (LAADS-DAAC)

1. Go to:

1 ladsweb.modaps.eosdis.nasa.gov

2. Create a username and profile

3. Click "Find Data"



The screenshot shows the LAADS DAAC website interface. The top navigation bar includes a search bar, 'About LAADS', 'Find Data' (highlighted with a red box and the number 3), 'Data Discovery', 'Quality', 'Help', and 'Profile' (highlighted with a red box and the number 2). Below the navigation bar are tabs for 'Missions', 'Level-0 / Level-1', 'Atmosphere', 'Airborne', and 'Land'. The main content area displays six data product thumbnails: Aqua MODIS, Terra MODIS, SNPP | JPSS-1 VIIRS, Envisat MERIS, Sentinel-3 OLCI, and Sentinel-3 SLSTR.



Downloading Black Marble Images via LAADS

The screenshot displays the LAADS DAAC website interface. The top navigation bar includes the NASA logo, the text "LAADS DAAC", and several menu items: "About LAADS", "Find Data", "Data Discovery", "Quality", "Help", and "Profile". Below the navigation bar is a search and filter section with a red border. This section contains a progress bar with five steps: "1 PRODUCTS", "2 TIME", "3 LOCATION", "4 FILES", and "5 REVIEW & ORDER". Below the progress bar are four filter boxes: "No products selected.", "No date selected.", "No location selected.", and "No files selected.", followed by a "reset" button. Below the filters are two dropdown menus: "All Sensors" and "All Searchable Collections". To the right of these dropdowns is a search input field labeled "keyword" and a "Browse products" checkbox. Below the search and filter section is a list of data products, each with an information icon (i) on the right. The products listed are:

- AERDB_D3_VIIRS_SNPP**: VIIRS/SNPP Deep Blue Level 3 daily aerosol data, 1x1 degree grid
- AERDB_L2_VIIRS_SNPP**: VIIRS/SNPP Deep Blue Aerosol L2 6-Min Swath 6 km
- AERDB_M3_VIIRS_SNPP**: VIIRS Deep Blue Level 3 monthly aerosol data, 1x1 degree grid
- AERDT_L2_VIIRS_SNPP**: VIIRS/SNPP Dark Target Aerosol L2 6-Min Swath 6 km
- ALBWS066**: MODIS-derived 0.66 micron white-sky albedo on a global, 1-minute equal angle grid
- ALBWS086**: MODIS-derived 0.86 micron white-sky albedo on a global, 1-minute equal angle grid

On the left side of the interface, there is a vertical sidebar with several icons and labels: "Search by Product", "Online Archive", "Filename Search", "Image Viewer", "Load/Save Search", and "Past Orders".



Downloading Black Marble Images via LAADS Web Portal

The screenshot displays the LAADS DAAC web portal interface. At the top, there is a navigation bar with the NASA logo and the text 'LAADS DAAC'. To the right of the logo are several menu items: 'About LAADS', 'Find Data', 'Data Discovery', 'Quality', 'Help', and 'Profile'. Below the navigation bar is a search bar with a dropdown menu showing 'Products (Collection)' and 'Add product VNP46A2 (5000)'. The search bar contains the text 'vnp46a2'. To the right of the search bar is a 'Browse products' button. Below the search bar is a list of search results. The first result is highlighted in green and is labeled 'VNP46A2' with a checkmark. The description for this result is 'VIIRS/NPP Gap-Filled Lunar BRDF-Adjusted Nighttime Lights Daily L3 Global 500m Linear Lat Lon Grid'. A red box highlights the 'REVIEW & ORDER' button in the top navigation bar. Red arrows point from the search bar to the search results and from the 'REVIEW & ORDER' button to the search results.

- In the search bar, type “VNP46A2”
- Select the dataset
- Dataset added



Downloading Black Marble Images via LAADS Web Portal

The screenshot displays the LAADS DAAC web portal interface. The top navigation bar includes the NASA logo, the text "LAADS DAAC", and several menu items: "About LAADS", "Find Data", "Data Discovery", "Quality", "Help", and "Profile". Below this is a search progress bar with five steps: 1. PRODUCTS, 2. TIME (highlighted), 3. LOCATION, 4. FILES, and 5. REVIEW & ORDER. The "TIME" step is further detailed with filters: "VNP46A2 (5000)", "2014-08-01" (highlighted), "No location selected.", "No files selected.", and a "reset" button. On the left sidebar, there are icons for "Search by Product", "Online Archive", "Filename Search", "Image Viewer", "Load/Save Search", and "Past Orders". The main content area is divided into two panels. The left panel shows "Date Range" and "Single Date" options (both highlighted), a "Display as:" dropdown set to "YYYY-MM-DD", a calendar icon with "2014-08-01" selected, and an "Add Date" button. The right panel shows a "Date Selection:" section with "2014-08-01" entered in a text box and a "Clear All" button. At the bottom, the "Coverage Selection:" section has three options: "Day" (checked), "Night" (unchecked), and "Day-Night Boundary" (checked), each with a brief description of the data granules.

NASA LAADS DAAC

About LAADS Find Data Data Discovery Quality Help Profile

1 PRODUCTS 2 TIME 3 LOCATION 4 FILES 5 REVIEW & ORDER

VNP46A2 (5000) 2014-08-01 No location selected. No files selected. reset

Date Range Single Date

Display as: YYYY-MM-DD

2014-08-01 Add Date

+ Advanced

Date Selection: Clear All

2014-08-01

Coverage Selection:

- Day (granules contain day data only)
- Night (granules contain night data only)
- Day-Night Boundary (granules contain data over the seasonal, latitude boundary between day and night)



Downloading Black Marble Images via LAADS Web Portal

The screenshot displays the LAADS DAAC web portal interface. At the top, the NASA logo and 'LAADS DAAC' are visible, along with navigation links: 'About LAADS', 'Find Data', 'Data Discovery', 'Quality', 'Help', and 'Profile'. Below the header is a search bar with 'Search by Product' and a navigation menu with five steps: 1. PRODUCTS, 2. TIME, 3. LOCATION (highlighted), 4. FILES, and 5. REVIEW & ORDER (with a right arrow button). The search parameters are: 'VNP46A2 (5000)', '2014-08-01', and 'W: -86.6°, N: 32.4°, E: -77.8°, S: 24.2°'. A 'reset' button is also present. The main area shows a satellite map of the Caribbean region with a red box highlighting a specific area. On the right, a 'SELECT AREA OF INTEREST' dropdown menu is open, listing options: 'World', 'Countries', 'Tiles', 'Validation Sites', 'Draw Custom Box (Classic)' (selected), and 'Enter Coordinates'. Below the menu, the 'Current selection:' is shown as 'W: -86.6°, N: 32.4°, E: -77.8°, S: 24.2°'. The left sidebar contains various utility buttons: 'Online Archive', 'Filename Search', 'Image Viewer', 'Load/Save Search', and 'Past Orders'.



Downloading Black Marble Images via LAADS Web Portal



LAADS DAAC

About LAADS Find Data Data Discovery Quality Help Profile

1 PRODUCTS 2 TIME 3 LOCATION 4 FILES 5 REVIEW & ORDER

VNP46A2 (5000) 2014-08-01 W: -86.6°, N: 32.4°, E: -77.8°, S: 24.2° 4 files selected reset

* Download selected files as json or csv

Search: Select All Clear All Query Results Selected (4) Images

Filename	Product (collection)	Date / Time	Download
VNP46A2.A2014213.h10v06.001.2020205215414.h5	VNP46A2 (5000)	2014-08-01 00:00:00	840 kB
VNP46A2.A2014213.h09v06.001.2020205221630.h5	VNP46A2 (5000)	2014-08-01 00:00:00	2 MB
VNP46A2.A2014213.h10v05.001.2020205225029.h5	VNP46A2 (5000)	2014-08-01 00:00:00	2 MB
VNP46A2.A2014213.h09v05.001.2020206120033.h5	VNP46A2 (5000)	2014-08-01 00:00:00	5 MB

Showing 1 to 4 of 4 entries Previous 1 Next

Search by Product Online Archive Filename Search Image Viewer Load/Save Search Past Orders



Downloading Black Marble Images via LAADS Web Portal

LAADS DAAC About LAADS Find Data Data Discovery Quality Help Profile

1 PRODUCTS 2 TIME 3 LOCATION 4 FILES 5 REVIEW & ORDER

VNP46A2 (5000) 2014-08-01 -86.6, 32.4, -77.8, 24.2 4 files selected reset

Files Summary:

VNP46A2 (Collection 5000) Total: 4 files ✕
2014-08-01 00:00:00 .. 2014-08-01 00:00:00]
The order will generate 4 files.

Post-processing not available.

Select Delivery Method

The order may generate as many as 4 files.

Add another search Submit Order



Downloading Black Marble Images via LAADS Online Archive

The screenshot displays the LAADS DAAC website interface. At the top, the NASA logo and 'LAADS DAAC' are visible on the left, and navigation links for 'About LAADS', 'Find Data', 'Data Discovery', 'Quality', 'Help', and 'Profile' are on the right. A progress bar at the top indicates five steps: 1. PRODUCTS, 2. TIME, 3. LOCATION, 4. FILES, and 5. REVIEW & ORDER. Below this, a status bar shows 'No products selected.', 'No date selected.', 'No location selected.', and 'No files selected.', with a 'reset' button. The main content area features dropdown menus for 'All Sensors' and 'All Searchable Collections', a search input field with the placeholder 'keyword', and a 'Browse products' checkbox. A list of product entries is shown, each with an information icon (i):

- AERDB_D3_VIIRS_SNPP**: VIIRS/SNPP Deep Blue Level 3 daily aerosol data, 1x1 degree grid
- AERDB_L2_VIIRS_SNPP**: VIIRS/SNPP Deep Blue Aerosol L2 6-Min Swath 6 km
- AERDB_M3_VIIRS_SNPP**: VIIRS Deep Blue Level 3 monthly aerosol data, 1x1 degree grid
- AERDT_L2_VIIRS_SNPP**: VIIRS/SNPP Dark Target Aerosol L2 6-Min Swath 6 km
- ALBWS066**: MODIS-derived 0.66 micron white-sky albedo on a global, 1-minute equal angle grid
- ALBWS086**: MODIS-derived 0.86 micron white-sky albedo on a global, 1-minute equal angle grid

A red box highlights the 'Online Archive' button in the left sidebar, which is the first step in the search process.



Downloading Black Marble Images via LAADS

The screenshot shows the LAADS DAAC website interface. At the top, there is a navigation bar with the NASA EarthData logo, 'Other DAACs', and utility icons for feedback and help. Below this is a secondary navigation bar with 'LAADS DAAC' and menu items for 'About LAADS', 'Find Data', 'Data Discovery', 'Quality', 'Help', and 'Profile'. The main content area shows the breadcrumb 'Home > LAADS Archive' and a search bar. The URL 'Index of /archive/allData/5000/VNP46A2/' is displayed and highlighted with a red box. Below the URL are buttons for 'Download Selected', 'See wget Download Command', 'Download Help', 'View as JSON', and 'View as CSV'. A table with columns 'Name', 'Last Modified', and 'Size' follows. The table contains a 'Parent directory' link and rows for years 2012 through 2017, all of which are highlighted with a red box. The 'Last Modified' column for all rows shows '2020-11-24 20:16'.

Name	Last Modified	Size
.. Parent directory		
2012	2020-11-24 20:16	-
2013	2020-11-24 20:16	-
2014	2020-11-24 20:16	-
2015	2020-11-24 20:16	-
2016	2020-11-24 20:16	-
2017	2020-11-24 20:16	-

You can also directly type the link

<https://ladsweb.modaps.eosdis.nasa.gov/archive/allData/5000/VNP46A2/>



Downloading Black Marble Images via LAADS Online Archive

The screenshot shows the LAADS DAAC website interface. The top navigation bar includes the NASA EarthData logo, 'Other DAACs', and links for 'About LAADS', 'Find Data', 'Data Discovery', 'Quality', 'Help', and 'Profile'. The main content area displays the 'Index of /archive/allData/5000/VNP46A2/2012/'. Below the title are buttons for 'See wget Download Command', 'Download Help', 'View as JSON', and 'View as CSV'. A table lists directories for each Julian Day from 019 to 028, all dated 2020-07-31 18:32. A red arrow points to the '020' entry.

Name	Last Modified	Size
.. Parent directory		
019	2020-07-31 18:32	-
020	2020-07-31 18:32	-
021	2020-07-31 18:32	-
022	2020-07-31 18:32	-
023	2020-07-31 18:32	-
024	2020-07-31 18:32	-
025	2020-07-31 18:32	-
026	2020-07-31 18:32	-
027	2020-07-31 18:32	-
028	2020-07-31 18:32	-

- Choose the Julian Day of interest*

*Julian Days for each year can be found here:

<https://landweb.modaps.eosdis.nasa.gov/browse/calendar.html>



Downloading Black Marble Images via LAADS



LAADS DAAC

Index of /archive/allData/5000/VNP46A2/2012/020/

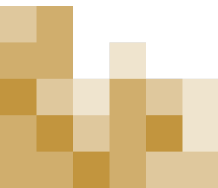
Multi-file downloads: Click individual table rows (or hold down Shift key for multiple) to select files followed by clicking "Download Selected" to confirm multi-file download

<input type="checkbox"/>	Select All		Last Modified	Size
..		Parent directory		
<input type="checkbox"/>	<input checked="" type="checkbox"/>	VNP46A2.A20120201.h00v01.001.2020038170951.h5	2020-02-07 17:16	199.3 kB
<input type="checkbox"/>	<input checked="" type="checkbox"/>	VNP46A2.A20120201.h00v02.001.2020038181229.h5	2020-02-07 18:55	1.1 MB
<input type="checkbox"/>	<input checked="" type="checkbox"/>	VNP46A2.A20120201.h00v03.001.2020038171032.h5	2020-02-07 17:16	196.0 kB
<input type="checkbox"/>	<input checked="" type="checkbox"/>	VNP46A2.A20120201.h00v04.001.2020038171011.h5	2020-02-07 17:16	132.6 kB
<input type="checkbox"/>	<input checked="" type="checkbox"/>	VNP46A2.A20120201.h00v05.001.2020038170832.h5	2020-02-07 17:15	132.6 kB

- Choose the file with your (h, v) grid coordinates of interest (Green boxes)*
- A rule of thumb to use is:

$$v = (90 - \text{lat}) / 10$$
$$h = (180 + \text{lon}) / 10$$

*You can download the spatial layer for the file grid boundary from this link <https://blackmarble.gsfc.nasa.gov/tools/BlackMarbleTiles.zip>



Converting HDF-5 to GeoTIFF

- If you are using Black Marble in a GIS software like ArcGIS or QGIS, you will want to convert the HDF-5 data to a GeoTIFF data format.
- Use our HDF-5 to GeoTIFF converter tool here:
 - <https://blackmarble.gsfc.nasa.gov/Tools.html>

Useful Tools

Some useful tools and guidance using NASA's Black Marble Products

Python scripts to read, convert (GeoTiff), and display (QGIS) VNP46 files. If you do not have GDAL install, you can use the QGIS python console (Plugins -> Python Console) to run the script.

HDF To GeoTiff

Download the source code to convert NASA's Black Marble HDF5 product to GeoTiff [HERE](#) and HDF4 product to GeoTiff [HERE](#)

Below are some details on using the tool

Location of the input folder containing HDF images

```
os.chdir('C:\\InputFolder')
```



Scientific Datasets Included with VNP46A2

Scientific Data Sets (SDS HDF Layers)	Units	Bit Types	Fill Value	Valid Range
DNB_BRDF-Corrected_NTL	nWatts ·cm ⁻² ·sr ⁻¹	16-bit unsigned integer	65,535	0 – 65,534
Gap_Filled_DNB_BRDF-Corrected_NTL	nWatts ·cm ⁻² ·sr ⁻¹	16-bit unsigned integer	65,535	0 – 65,534
DNB_Lunar_Irradiance	nWatts ·cm ⁻² ·sr ⁻¹	16-bit unsigned integer	65,535	0 – 65,534
Mandatory_Quality_Flag	Class Flag	8-bit unsigned integer	255	0 – 3
Latest_High_Quality_Retrieval	Number of days	8-bit unsigned integer	255	0 – 254
Snow_Flag	Class Flag	8-bit unsigned integer	255	0 – 1
QF_Cloud_Mask	Class Flag	16-bit unsigned integer	65,535	0 – 65,534

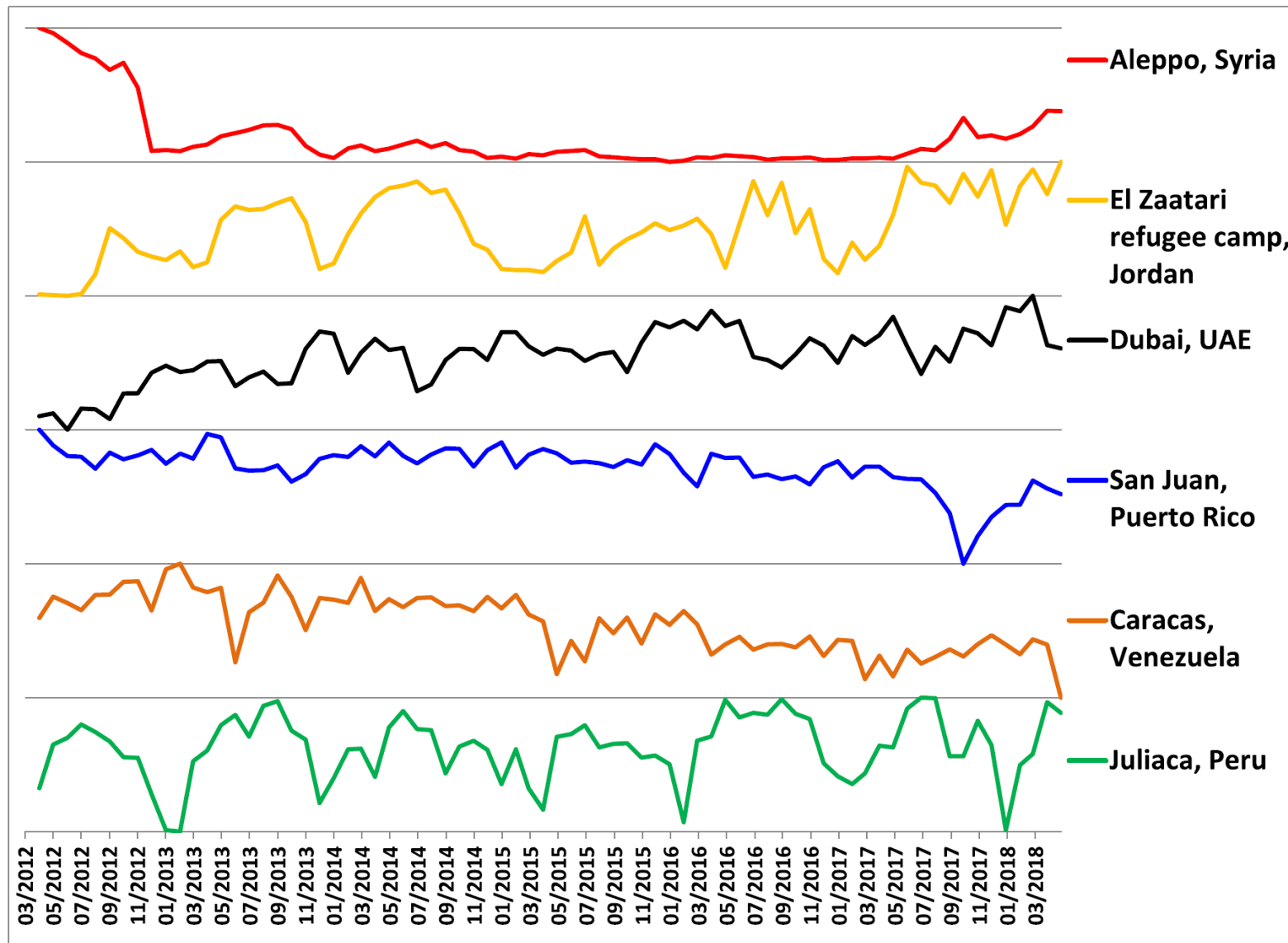
Considering QA indicators in the VNPA2 Product (DNB_BRDF-Corrected_NTL)

Value	Retrieval Quality	Algorithm Instance
00	High-quality	Main algorithm (persistent nighttime lights)
01	High-quality	Main algorithm (Ephemeral Nighttime Lights)
02	Poor-quality	Main algorithm (Outlier, potential cloud contamination or other issues)
255	No retrieval	Fill value



Part 3: Applying Black Marble Data

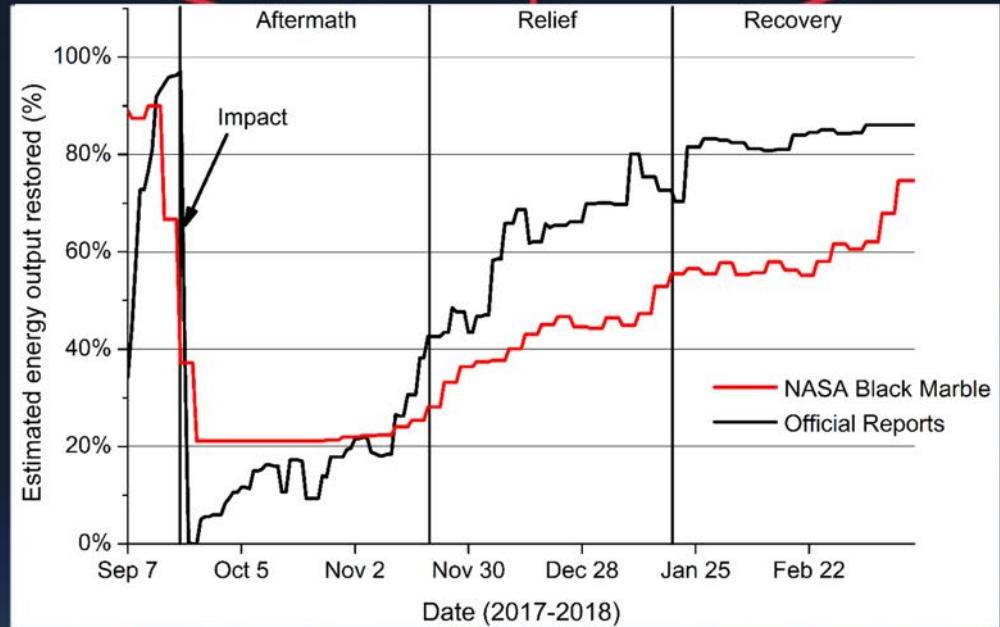
Case Study: Mapping Urban Areas and Urbanization



Monthly temporal changes in Black Marble nighttime brightness demonstrate various patterns. Each of the sites was normalized between its own min/max radiance values.



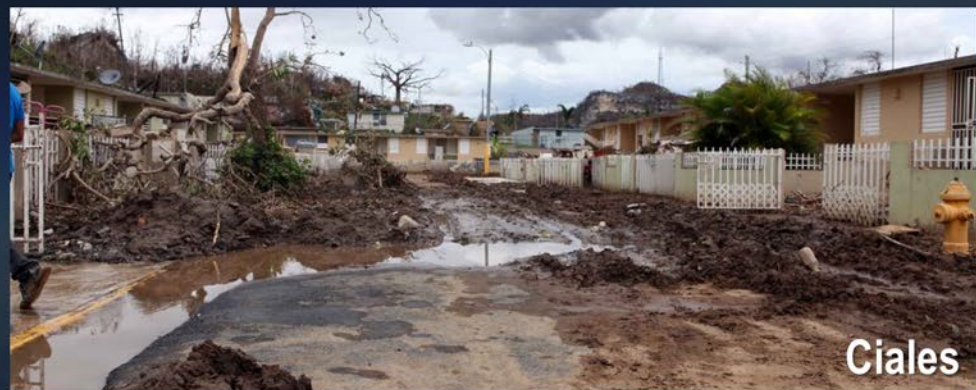
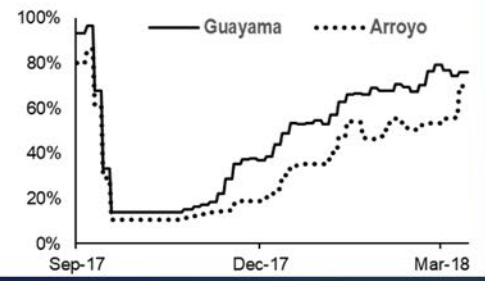
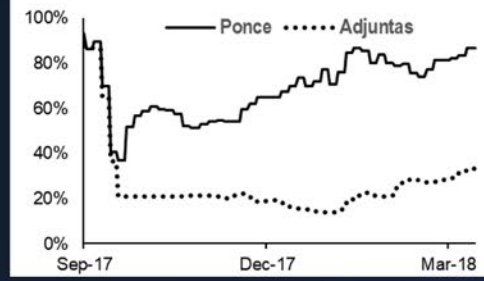
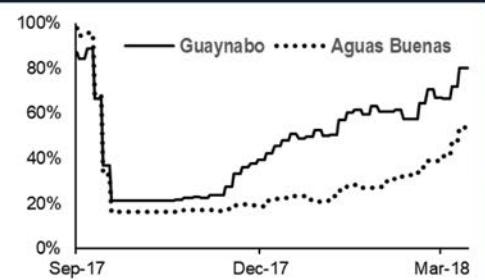
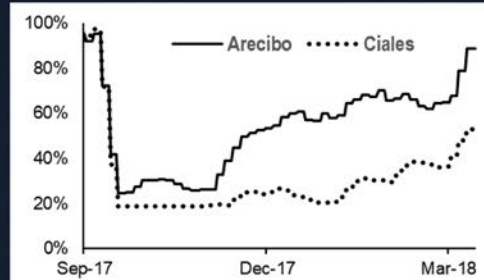
Monitoring Disaster Impacts in Puerto Rico (2017-2018)



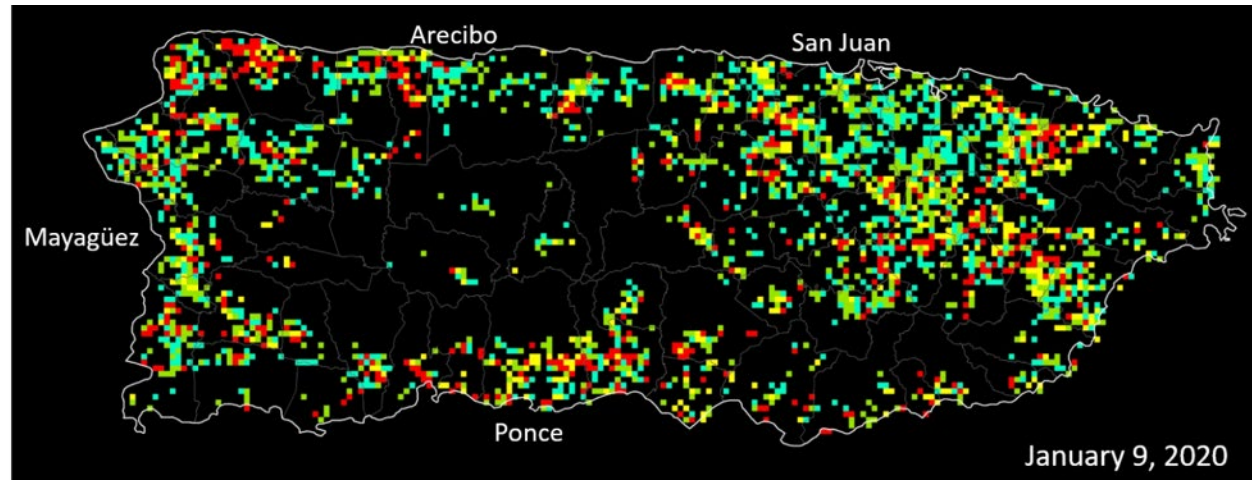
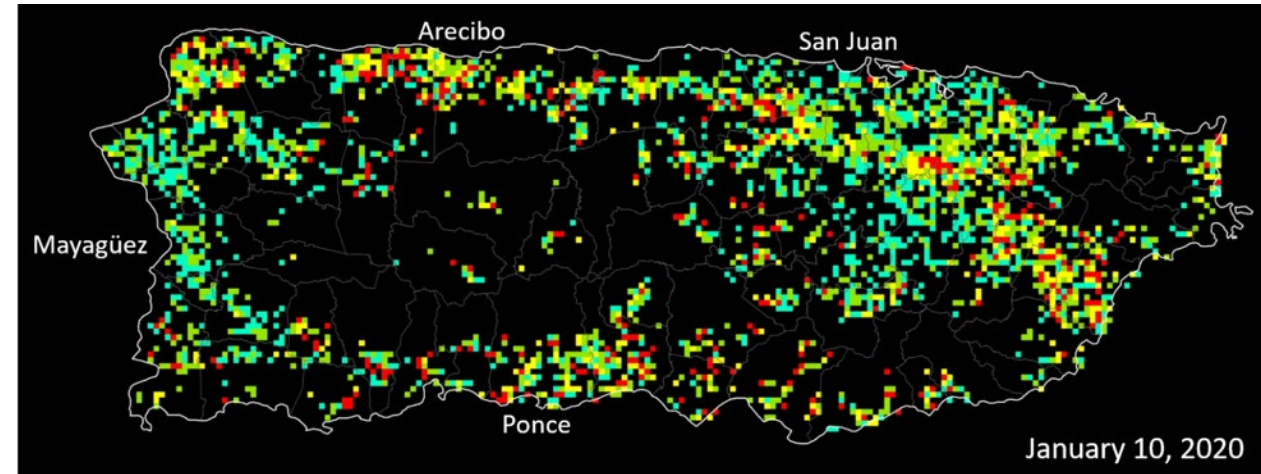
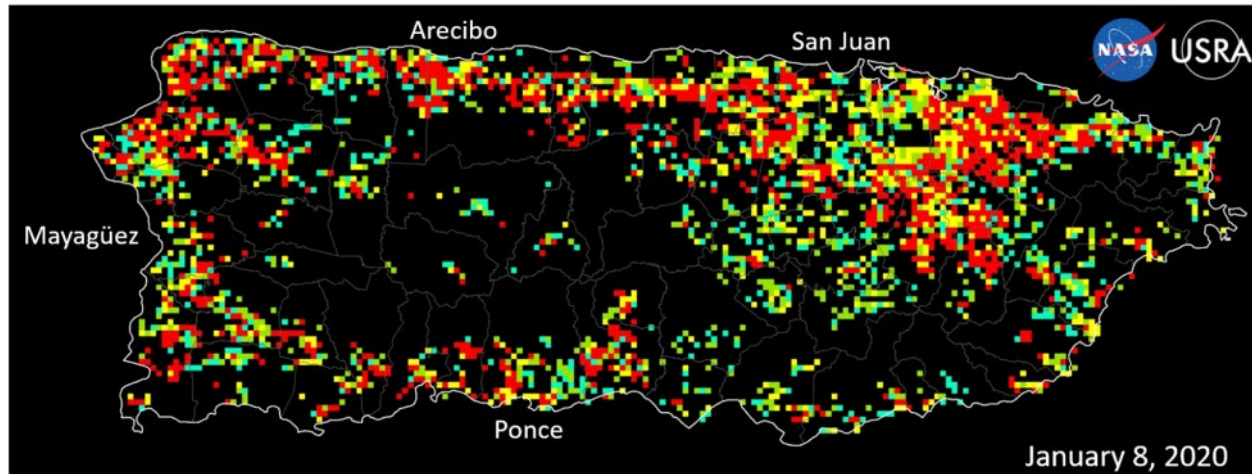
Estimated energy output restored after Hurricanes Irma and Maria (%)



Monitoring Disaster Impacts in Puerto Rico (2017-2018)



Monitoring Disaster Impacts in Puerto Rico – After Jan-2020 6.4 Earthquakes



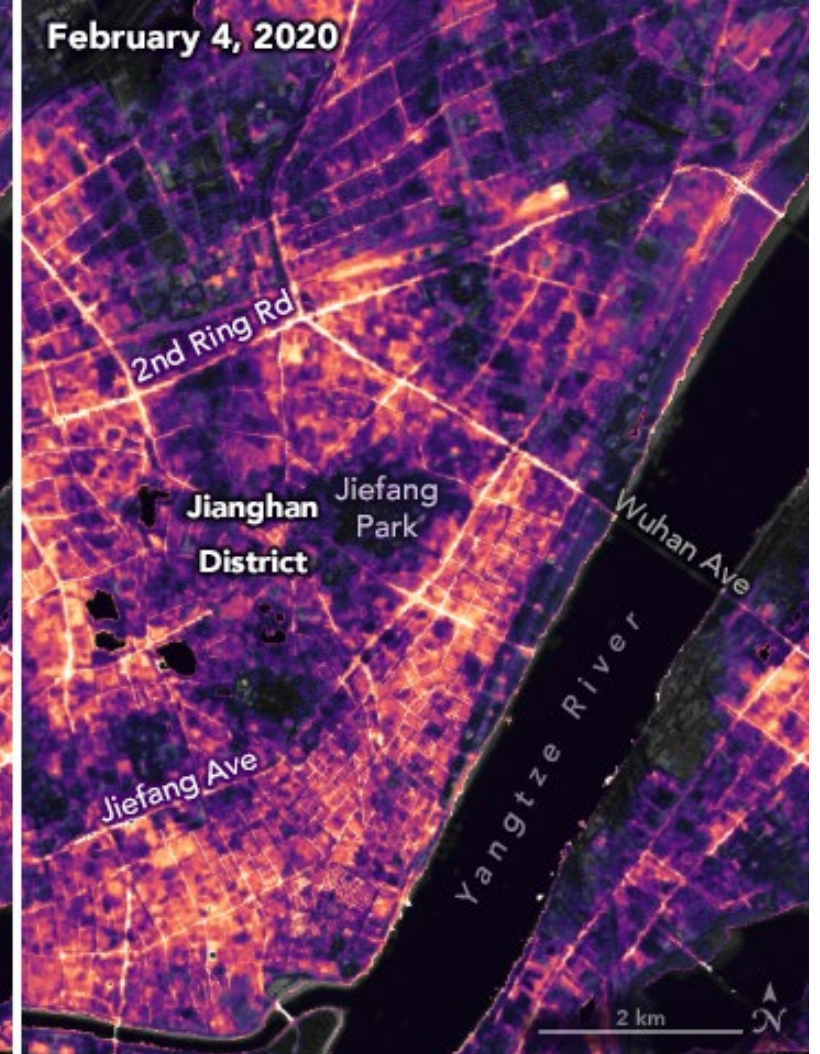
	Reduction in Outdoor Illumination	Radiance Decrease (%)	Population Affected on Jan 8	Population Affected on Jan 9	Population Affected on Jan 10
	Very High	75 – 100	666,259	214,623	142,207
	High	50 – 75	426,589	267,003	247,595
	Moderate	25 – 50	406,731	491,911	626,010
	Low	10 – 25	272,227	486,239	551,560

Reductions in outdoor illumination are widespread even after 3 days.

Román et al., (2019) PLoS One



Monitoring COVID-19 Impacts on Urban Areas



Loss of light is observed along highways (left) and inside the commercial districts of Wuhan (right) after the COVID-19 lockdown.



More Information

- Check out our Black Marble website at: <https://blackmarble.gsfc.nasa.gov/>
- These articles from our team are particularly useful:
 - *As a reference manual:*
 - Román, M. O., Z. Wang, Q. Sun, V. Kalb, S. D. Miller, A. Molthan, L. Schultz, J. Bell, E. C. Stokes, B. Pandey, K. C. Seto, D. Hall, T. Oda, R. E. Wolfe, G. Lin, N. Golpayegani, S. Devadiga, C. Davidson, S. Sarkar, C. Praderas, J. Schmaltz, R. Boller, J. Stevens, O. M. Ramos Gonzalez, E. Padilla, J. Alonso, Y. Detrés, R. Armstrong, I. Miranda, Y. Conte, N. Marrero, K. MacManus, T. Esch, and E. J. Masuoka. 2018. "NASA's Black Marble nighttime lights product suite." *Remote Sensing of Environment* 210 113-143 [[doi:10.1016/j.rse.2018.03.017](https://doi.org/10.1016/j.rse.2018.03.017)]
 - *Case study of disaster applications:*
 - M. O. Román, Eleanor C. Stokes, Ranjay Shrestha, Zhuosen Wang, Lori Schultz, Edil A. Sepúlveda Carlo, Qingsong Sun, Jordan Bell, Andrew Molthan, Virginia Kalb, Chuanyi Ji, Karen C. Seto, Shanna N. McClain, and Markus Enenkel. 2019. "Satellite-based assessment of electricity restoration efforts in Puerto Rico after Hurricane Maria." *PLoS ONE* 14 (6) [[doi:10.1371/journal.pone.0218883](https://doi.org/10.1371/journal.pone.0218883)]
 - *Application to urban activity patterns:*
 - Román, M. O., and E. C. Stokes. 2015. "Holidays in lights: Tracking cultural patterns in demand for energy services." *Earth's Future* 3 (6): 182-205 [[doi:10.1002/2014ef000285](https://doi.org/10.1002/2014ef000285)]
 - *General review of Nightlights and future outlook:*
 - Noam Levin, Christopher C. M. Kyba, Qingling Zhang, Alejandro Sánchez de Miguel, Miguel O. Román, Xi Li, Boris A. Portnov, Andrew L. Molthan, Andreas Jechow, Steven D. Miller, Zhuosen Wang, Ranjay M. Shrestha, Christopher D. Elvidge. 2020. "Remote sensing of night lights: A review and an outlook for the future." *Remote Sensing of Environment*. Volume 237 [[doi:10.1016/j.rse.2019.111443](https://doi.org/10.1016/j.rse.2019.111443)]



Downloading Black Marble Images via LAADS

To batch download many files, consider using OPenDAP URL syntax to refer to each file.

For example, to download Suomi-NPP-VIIRS VNP46A2 product from January 19, 2012, in grid H18v03 (London, United Kingdom), type into internet browser:

ladsweb.modaps.eosdis.nasa.gov/opendap/allData/5000/VNP46A2/2012/019/VNP46A2.A2012019.h18v03.001.2020038165547.h5.html

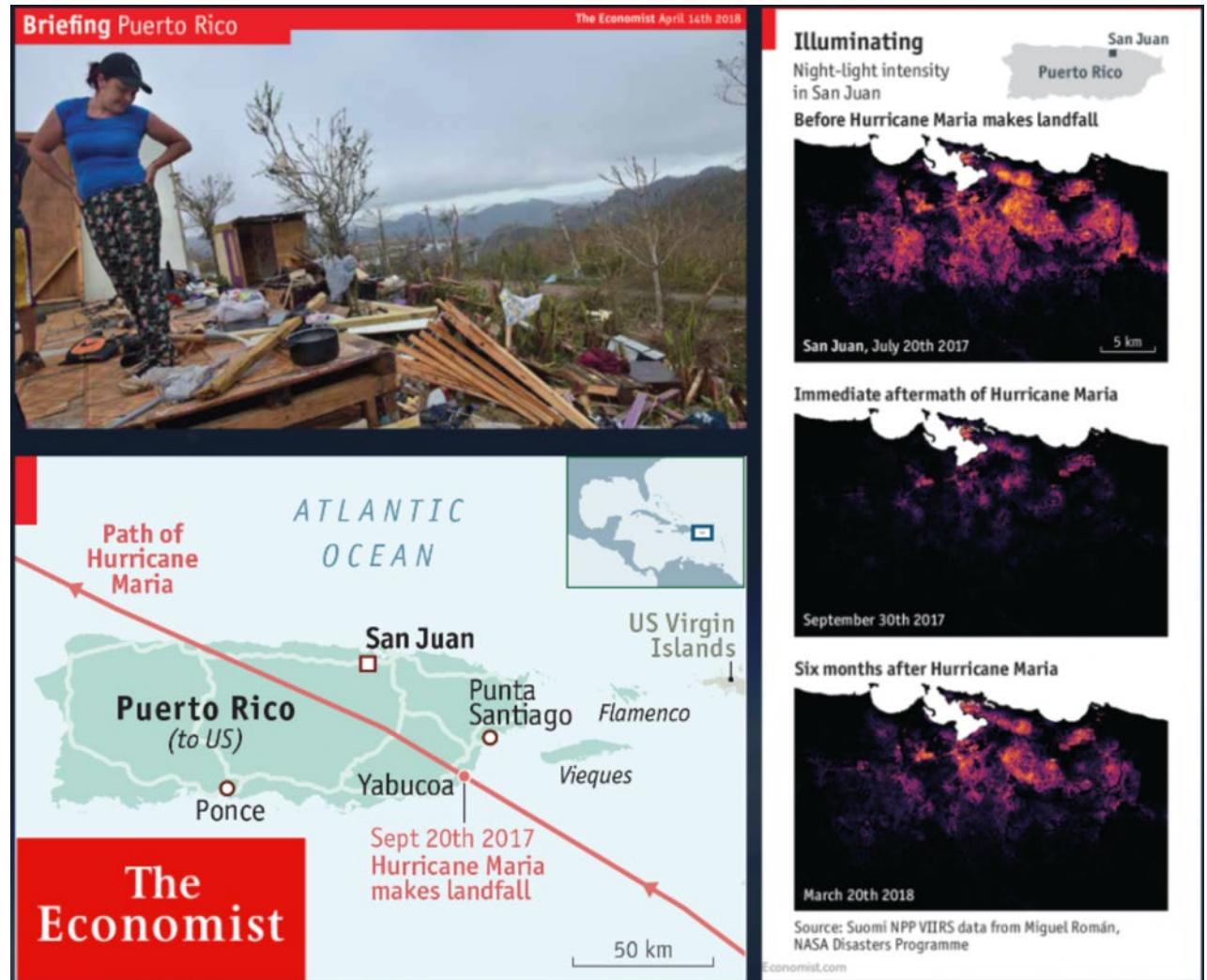




Practical Exercise

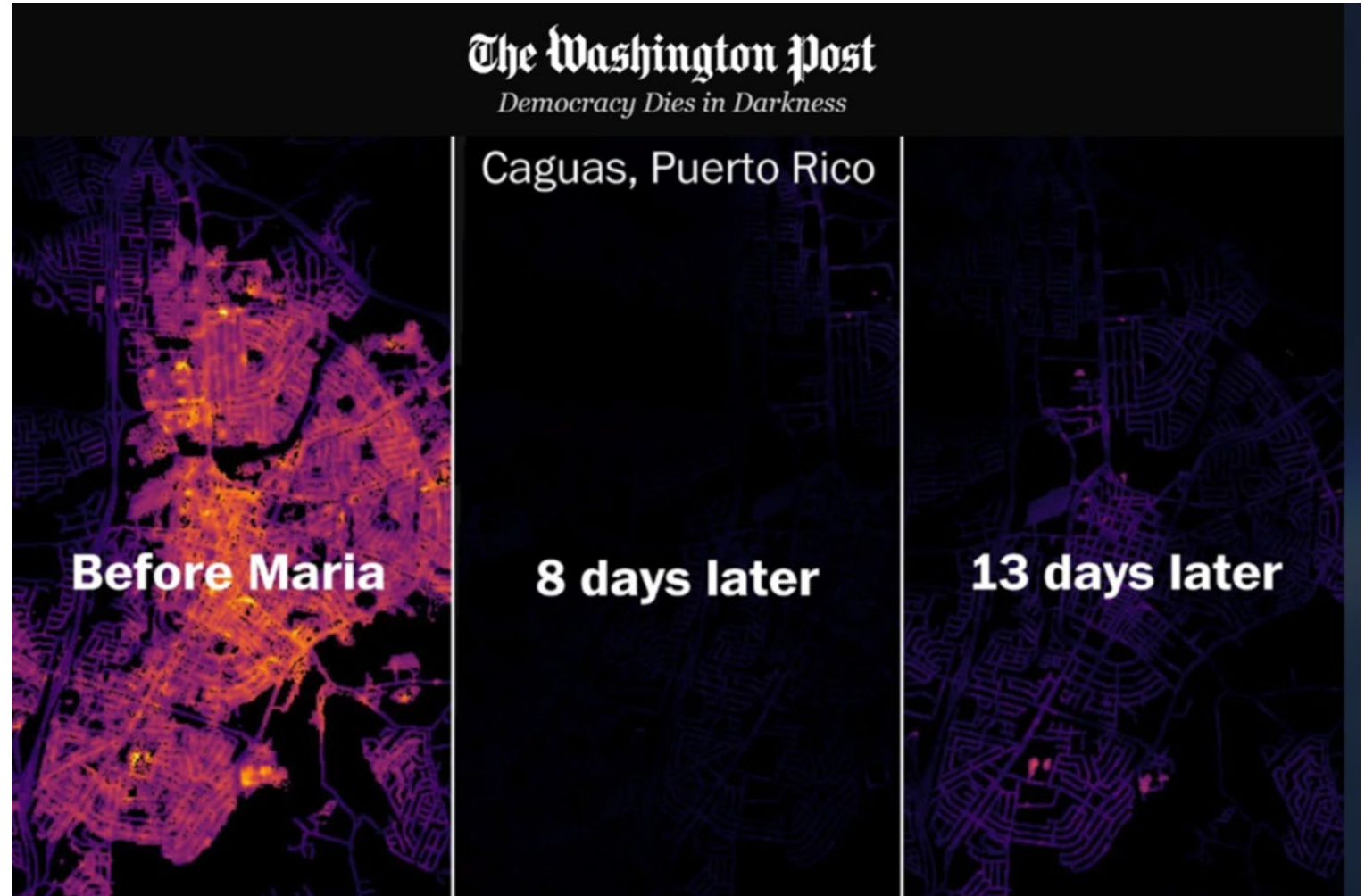
Case Study - Hurricane Maria in Puerto Rico

- Largest blackout in US history
- \$90 billion in damages
- -15% loss of gross national product (GNP)
- 4,645 human lives lost
- 200,000 people migrated



Generating Time-Series – Caguas, Puerto Rico

- Location – Caguas, PR
- Date range:
 - July 1, 2017
 - Oct 26, 2017



Generating Time-Series – Caguas, Puerto Rico

1. VNP46A2 Data

- Download data zipped folder here
- <https://drive.google.com/file/d/1BDWFgLdUFS8SGNlvR0ypwgQEQ9hHFhMO/view?usp=sharing>
- Extract the data in your local folder

2. Python Script

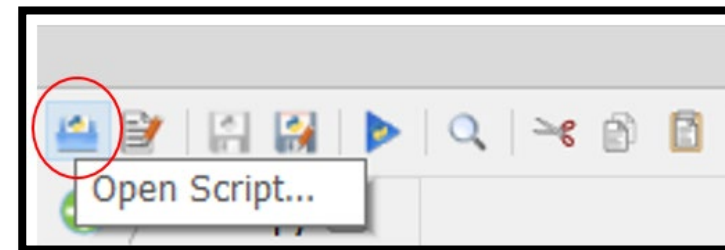
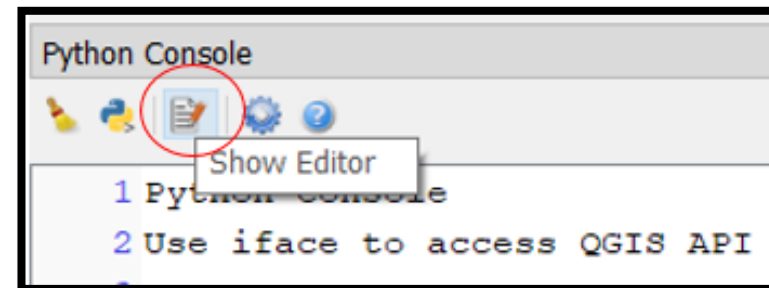
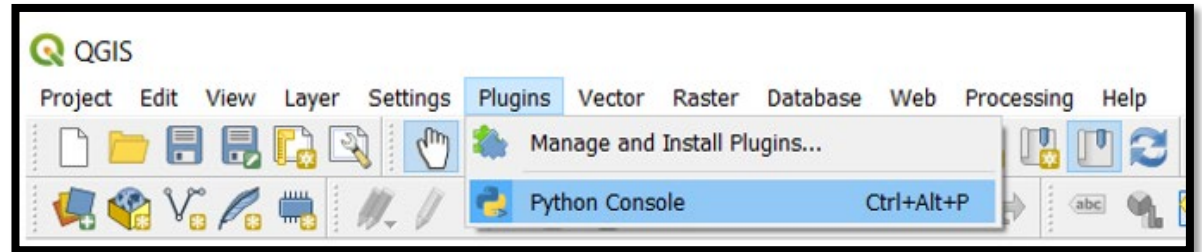
- Download the Python script here
- <https://drive.google.com/file/d/1rvD8Bp7GP8BZAg0hhVplctDpgj5ukJT/view?usp=sharing>
- Save it in your local folder



Generating Time-Series – Caguas, Puerto Rico

3. Executing the Python Script from QGIS

- Open QGIS
- From the **Plugins** menu, open **Python Console**.
- In the Python Console, click on the **Show Editor** icon.
- In the Editor, click on the **Open Script** icon, navigate to the Python Script you downloaded and open the script.



Generating Time-Series – Caguas, Puerto Rico

4. Code Update

- Once the Python Script is loaded in the editor, make the following **changes** in the script:

Line 11 – Change the folder path to the extracted VNP46A2 data folder you downloaded

```
>os.chdir('C:/ARSET/Assignment/Demo/Syria/Data_PR')
```

```
9 #Input·VNP46A2·--·PR
10 #####Change·it·to·your·input·Data·Folder###
11 os.chdir('C:/ARSET/Assignment/Demo/Maria2020/Data_PR')
```

Line 15 – Change the folder path to a separate local folder to hold temporary files

```
>outputFolder = "C:/ARSET/Assignment/Demo/Syria/Output/"
```

```
13 #Output·--·PR
14 #####Chage·This·Path·to·Output/Temp·Folder####
15 outputFolder = "C:/ARSET/Assignment/Demo/Maria2020/Output/"
```

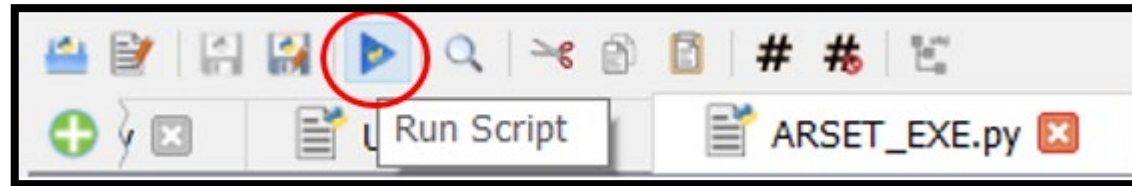
Note – Please use either “/” or “\” to define folder path.



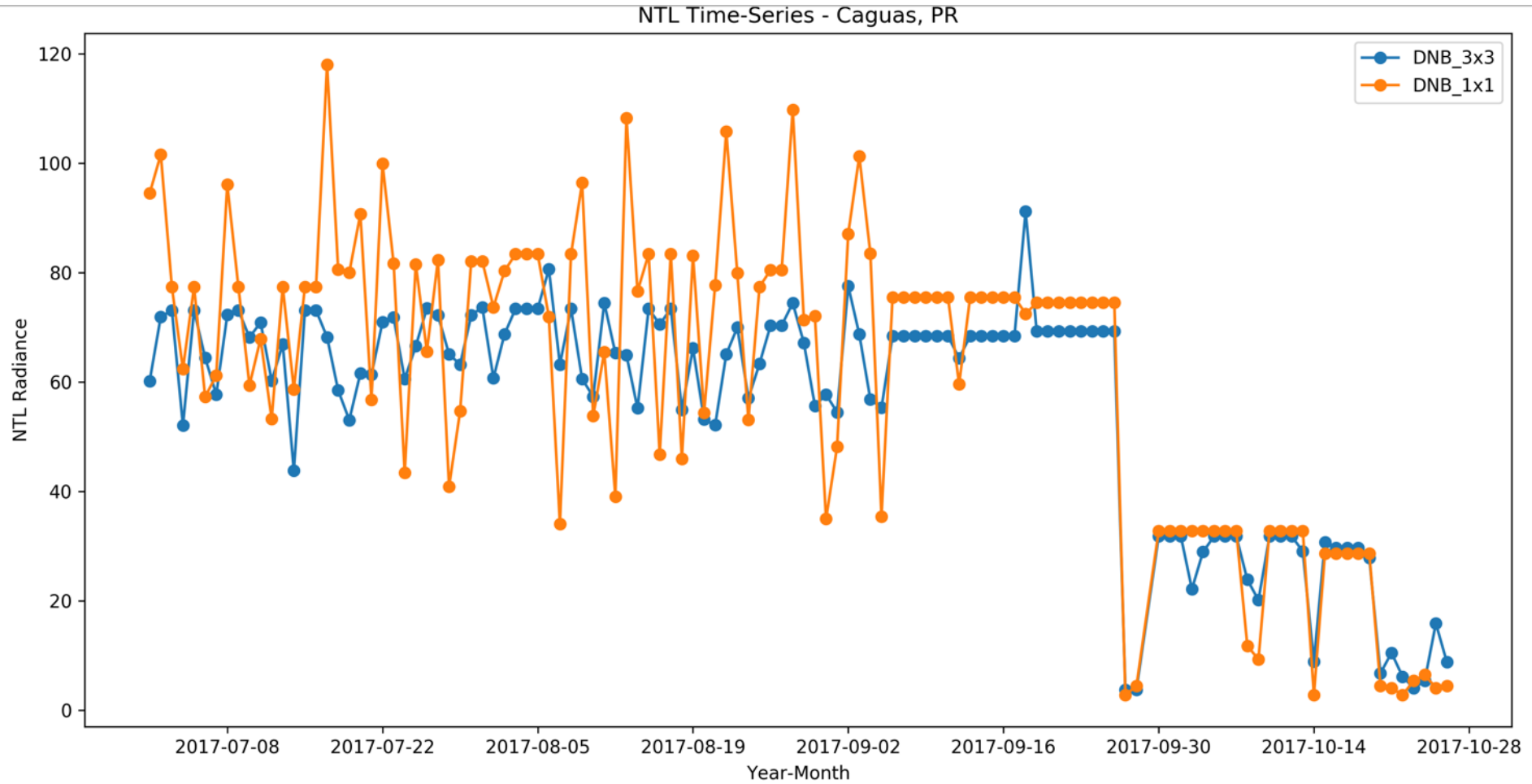
Generating Time-Series – Caguas, Puerto Rico

5. Executing the Python Script

- After the changes, execute the Python Script by clicking the **Run Script** icon.



Generating Time-Series – Caguas, Puerto Rico



3x3 pixel window-based time-series, smoother compared to a single (1x1) pixel-based.





Thank You!

