National Aeronautics and
Space Administration

A Changing Earth *at* Night

2012 - 2016

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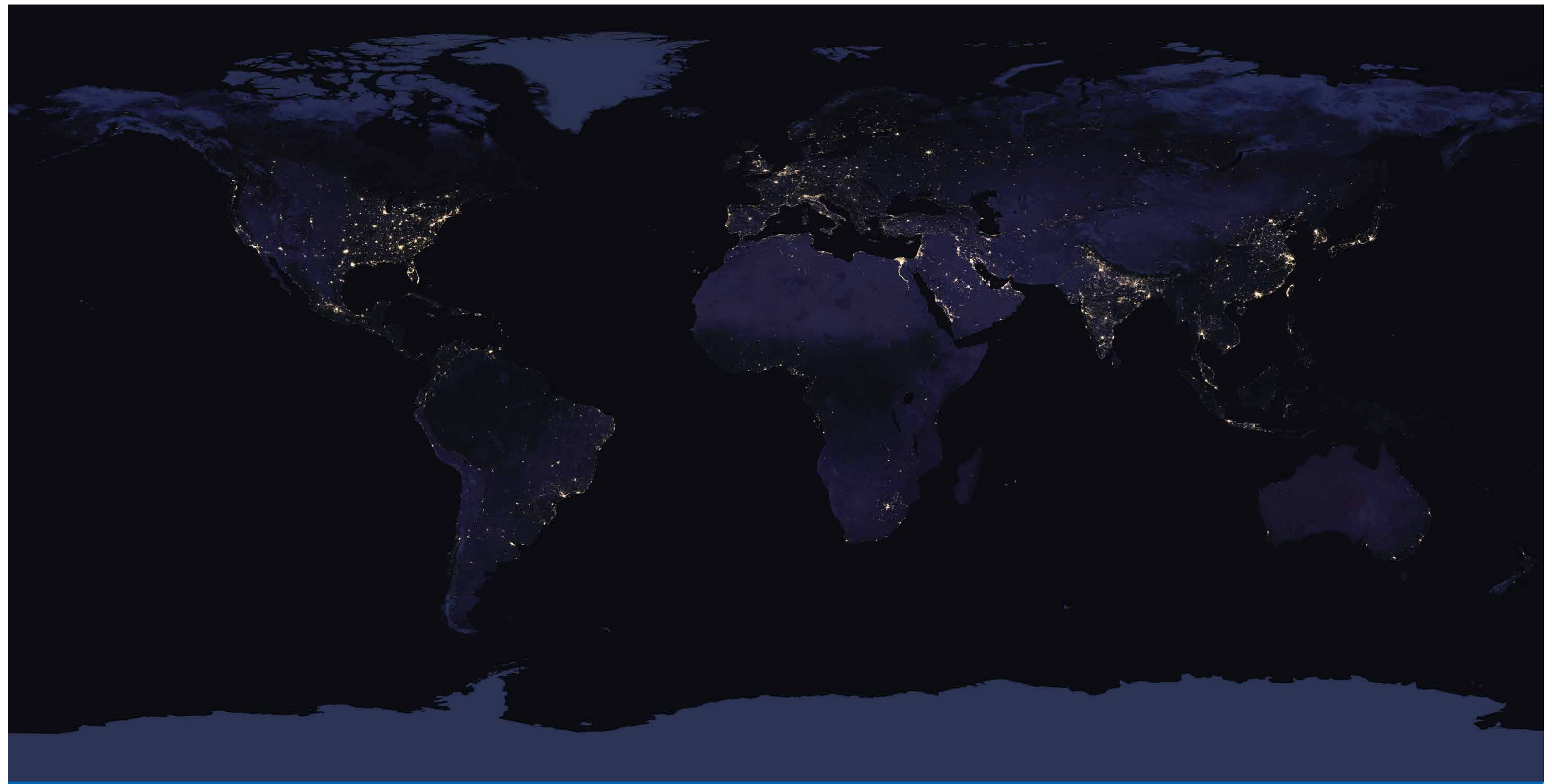
The map on the front of the poster shows the change in lighting intensity from 2012 to 2016. The map was created using two separate night lights datasets (from 2012 and 2016) derived using data from the Visible Infrared Imaging Radiometer Suite (VIIRS) on the National Oceanic and Atmospheric Administration (NOAA)-NASA Suomi National Polar-orbiting Partnership (NPP) satellite. Each pixel represents 500 meters (1640 feet), or approximately six city blocks. Dark purple represents areas with new light since 2012, while dark orange represents areas where light existed in 2012 but no longer exists in 2016. Areas where lighting intensity stayed the same between 2012 and 2016 appear white. Varying shades of purple and orange indicate areas that have become brighter or dimmer since 2012, respectively.



NASA's Black Marble • Earth *at* Night 2016

Satellite images of Earth at night—often referred to as "night lights"—have been a gee-whiz curiosity for the public and a tool for fundamental research for nearly 25 years. They have provided a broad, beautiful picture, showing how humans have shaped the planet and lit up the darkness. Produced every decade or so, such maps have spawned hundreds of pop-culture uses and dozens of economic, social science, and environmental research projects.

The 2016 Earth at Night image, dubbed NASA's Black Marble, was created with data from the Suomi National Polar-orbiting Partnership (NPP) satellite launched in October 2011 by NASA, the National Oceanic and Atmospheric Administration, and the U.S. Department of Defense. The data used in the 2016 version [*shown above*] were acquired over 190 days in 2016. This translates into 5247 orbits and 42 terabytes of input data to get a clear enough shot of the Earth's land surface and ocean. Scientists have observed the Earth's lights at night for more than four decades using military satellites and astronaut photography; however, the view became significantly clearer after using satellite data from a low-light sensor onboard Suomi NPP that can distinguish night lights with four times better spatial resolution and 250 times better resolution of lighting levels than before.

An earlier, popularized version of Earth at night was created using data from the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS). Thanks to advancements in sensor technology and improved optics, the Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) "Day-Night Band" (DNB) is ten to fifteen times better than the OLS sensor at resolving the relatively dim lights of human settlements and reflected moonlight. Each pixel shows roughly 0.46 miles (742 meters) across, compared to the 1.86-mile (3-kilometer) footprint of OLS—see example showing night lights data in 2003, 2012, and 2016 for Chicago, Illinois [*right*]. Beyond the resolution, the sensor can detect dimmer light sources.

Unlike a film camera that captures a photograph in one exposure, VIIRS produces an image by repeatedly scanning a scene (increasing exposure time) and resolving it as millions of individual picture elements, or pixels. The DNB goes a step further, determining on-the-fly whether to use its low, medium, or high-gain mode. If a pixel is very bright, a low-gain mode on the sensor prevents the pixel from oversaturating. If the pixel is dark, the signal will be amplified.

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CHICAGO, ILLINOIS

2003 OLS Earth at Night, Chicago, IL **2012** VIIRS Earth at Night, Chicago, IL **2016** VIIRS Earth at Night, Chicago, IL

[*Above*] The images above show the area surrounding Chicago, Illinois, using night lights data from the Operational Linescan System (OLS) onboard the Defense Meteorological Satellite Program (DMSP) satellite released in 2003 [*left*], the VIIRS DNB in 2012 [*middle*], and the VIIRS DNB in 2016 [*right*]. When you look at the images side by side, the OLS image appears coarse and blurry compared to the high-precision VIIRS images from 2012 and 2016. The most readily noticeable difference in these nighttime composite views of Chicago and surrounding areas in 2012 and 2016 is lighting along a recently expanded section of Interstate 90. This part of the highway, the Jane Addams Memorial Tollway, links Chicago with Rockford, Illinois, to the northwest.

IMAGE CREDITS:

Data: NASA and the National Oceanic and Atmospheric Administration (NOAA) Suomi NPP VIIRS data

Data processing: NASA Goddard Space Flight Center's Terrestrial Information Systems Laboratory

Image composite: NASA Earth Observatory

LINKS:
https://earthobservatory.nasa.gov/Features/NightLights
https://earthobservatory.nasa.gov/Features/NightLights/page3.php
https://viirsland.gsfc.nasa.gov
https://science.gsfc.nasa.gov/earth/terrestrialinfo
https://disasters.nasa.gov

Using Night Lights Data to Study Our Planet at Night

People tend to live where it is easy to make a living, resources are plentiful, the climate is moderate, and the land isn't too rugged. One way to study the spatial distribution, or arrangement, of human settlements is to view the planet from space during nighttime hours. As you look at the Earth at night, you can see the patterns of distribution. For example, most major cities are along coastlines, near rivers, or near transportation networks.

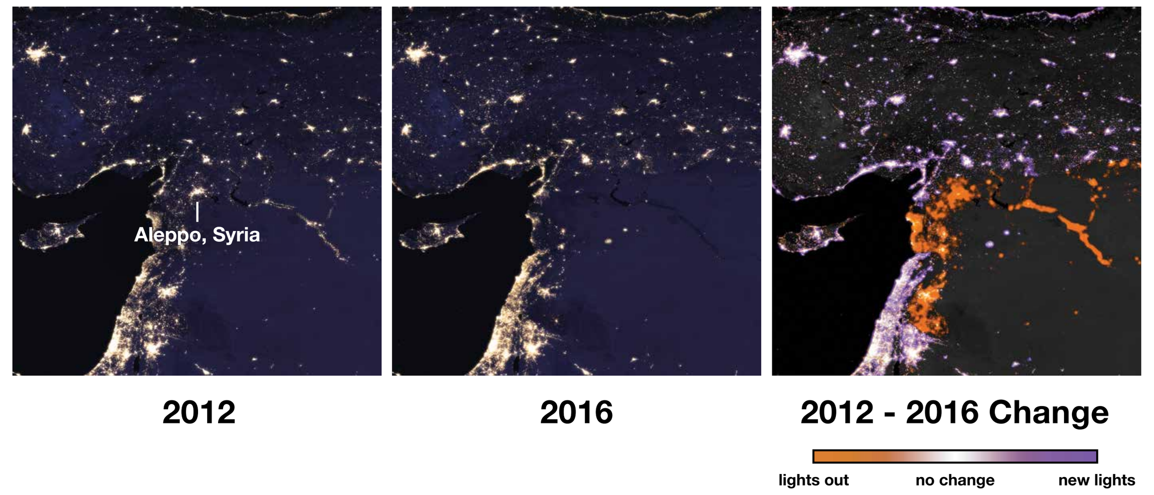
The brightest areas are generally the most urbanized, but not necessarily the most populated. When a city or country is thriving, electricity is used to keep businesses, schools, and factories bustling with activity. The stable lights show how far urban sprawl extends and areas where growth is occurring or has not yet occurred. Cities usually have many people concentrated in a small area, so electricity usage is high. Poor areas may have large populations, but low usage of electric lights to conserve money.

Scientists use the Suomi NPP night lights dataset in many ways. Some applications include:

- *forecasting a city's energy use and carbon emissions,*
- *eradicating energy poverty and fostering sustainable energy development,*
- *providing immediate information when disasters strike, and*
- *monitoring the effects of conflict and population displacement.*

Scientists at NASA are working to automate nighttime VIIRS data processing so that data users are able to view nighttime imagery within hours of acquisition. This capability can be reached through NASA Worldview (*https://worldview.earthdata.nasa.gov*), and has the potential to aid disaster response. The NASA team envisions many new potential uses by research, meteorological, civic, and humanitarian groups.

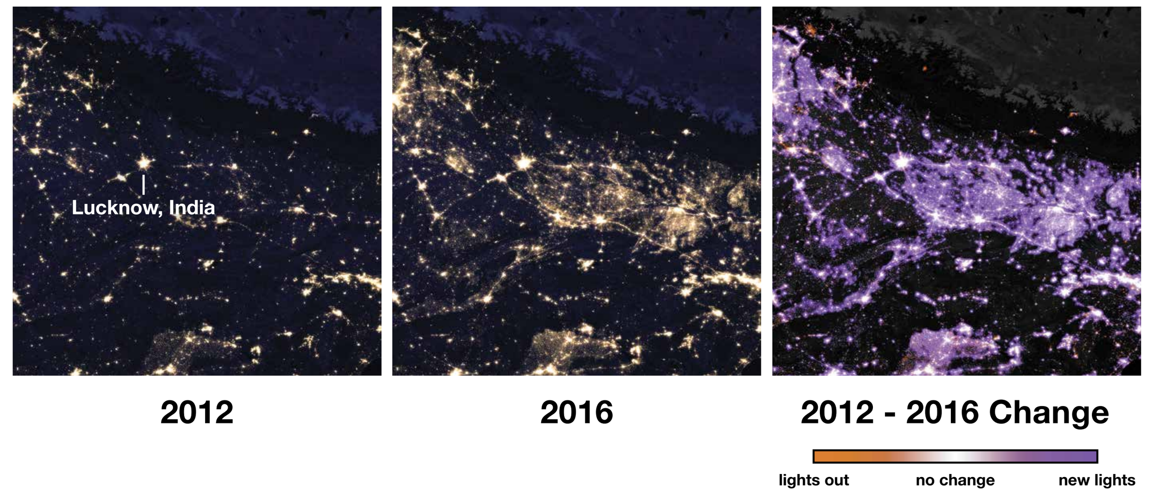
MIDDLE EAST



2012 **2016** **2012 - 2016 Change**

Six years of war in Syria have had a devastating effect on millions of its people. One of the most catastrophic impacts has been on the country's electricity network. These images clearly show how the lights have gone out during the course of the conflict, leaving people to survive with little to no power. Syria was once one of the eastern Mediterranean's major power suppliers. It has 15 power stations, including three major hydroelectric dams.

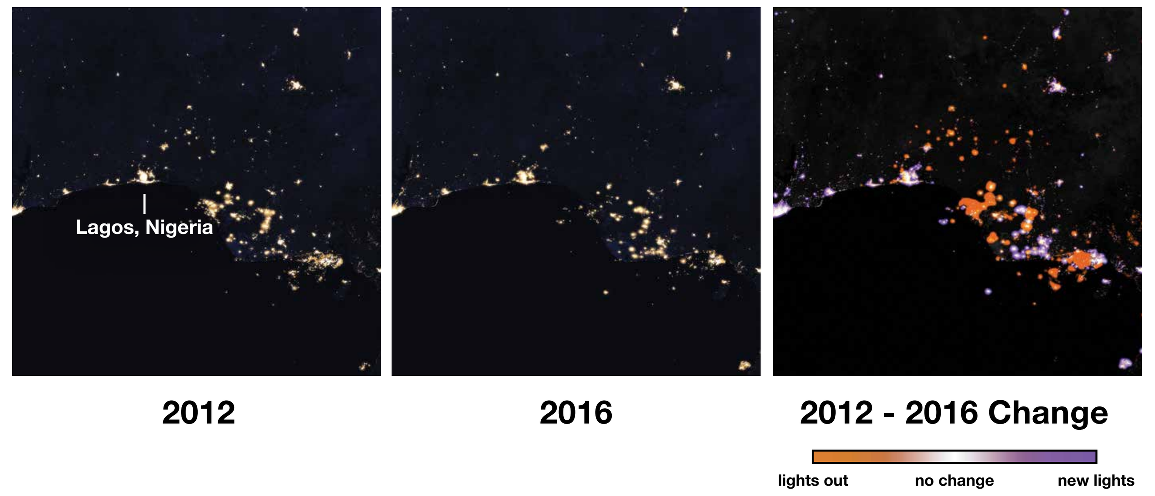
INDIA



2012 **2016** **2012 - 2016 Change**

NASA's Black Marble products are also being used by scientists and decision-makers to monitor gradual changes driven by urbanization, out-migration, economic changes, and electrification. These images show the rapid electrification of India's rural settlements in recent years. Huge swaths of northern India, relatively dark in 2012 night shots, are lit up in NASA's Black Marble imagery from 2016.

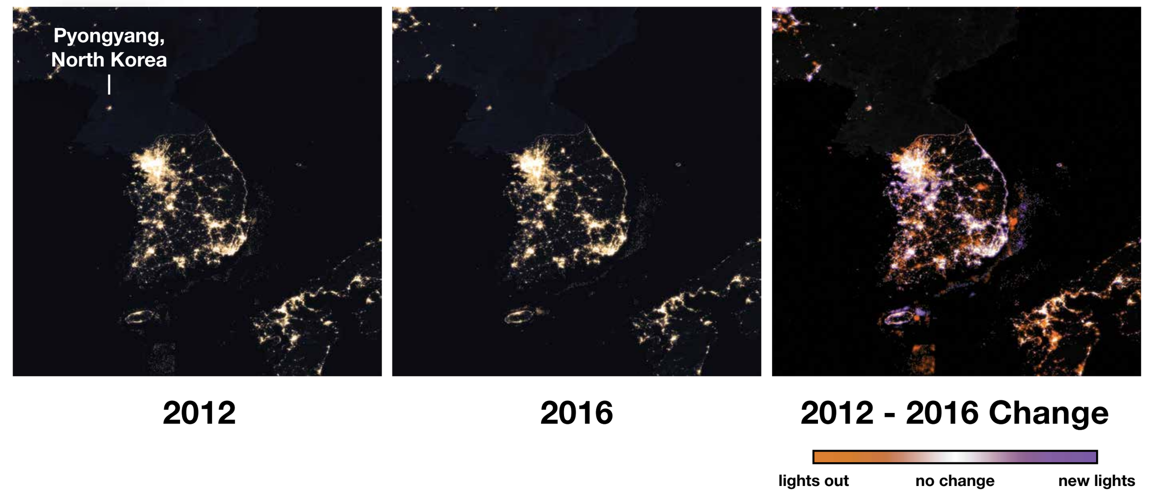
WEST AFRICA



2012 **2016** **2012 - 2016 Change**

Gas flaring is a globally-used method to dispose flammable, toxic, or corrosive vapors to less-reactive compounds at oil production sites and refineries. This practice leads to significant increases of carbon emissions into the atmosphere. Gas flaring is also responsible for particulate matter, sulfur dioxide, nitrogen oxide, methane, and carcinogenic substances such as benzene and toluene. Light from gas flaring activity in Nigeria decreased from 2012 to 2016, largely due to international agreements acted on by the country.

KOREAN PENINSULA

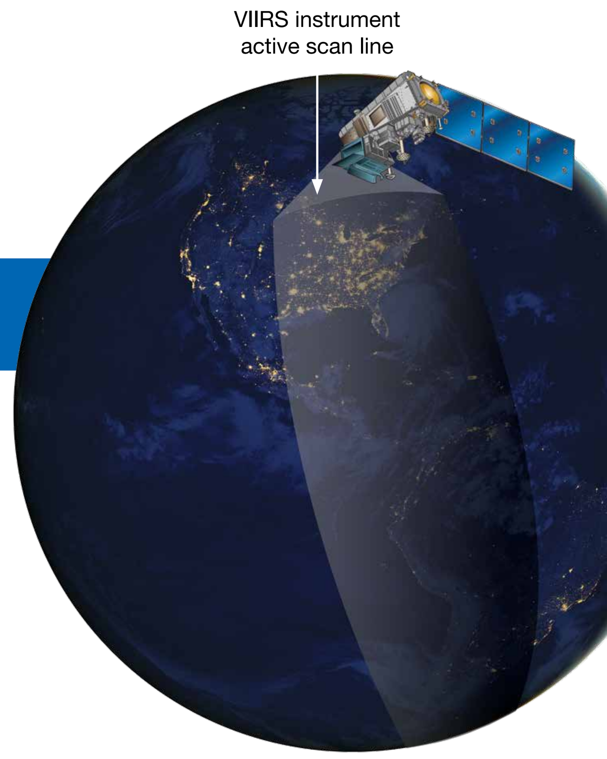


2012 **2016** **2012 - 2016 Change**

City lights at night are a fairly reliable indicator of where people live; however, this isn't always the case, and the Korean Peninsula shows why. As of July 2012, South Korea's population was estimated at roughly 49 million people, and North Korea's population was estimated at about half that number. But where South Korea is gleaming with city lights, North Korea has hardly any lights at all—just a faint glimmer around Pyongyang. Daily nighttime images are also being used to help monitor unregulated or unreported fishing. The 2012 image shows the lights of fishing boats south of the Korean Peninsula. These fishing boats disappeared in 2016.

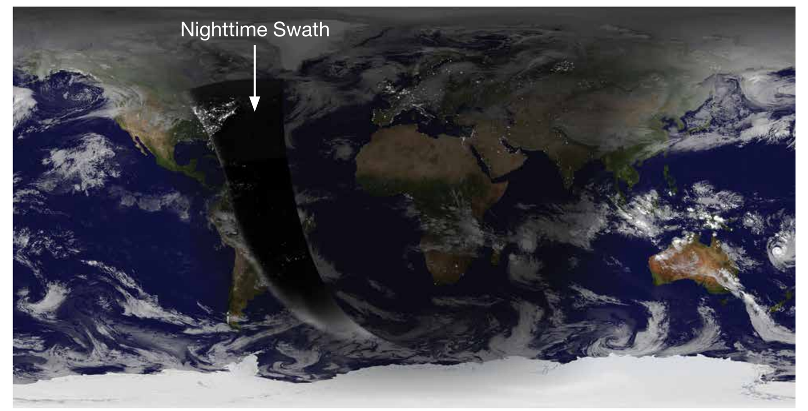
How Was NASA's Black Marble Made?

1

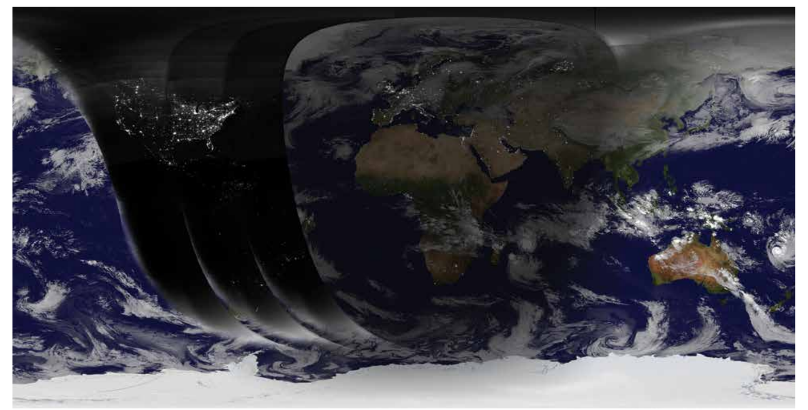


In its orbit, Suomi NPP flies 512 miles (824 kilometers) above the Earth, crossing the Equator at roughly 1:30 AM and 1:30 PM local time while circling the planet from pole to pole and back about 14 times a day. The Visible Infrared Imaging Radiometer Suite (VIIRS) onboard is a multi-spectral scanning radiometer that scans 1889-mile (3040-kilometer) wide swaths of data.

2 The Suomi NPP satellite observes the Earth's surface twice every 24-hour day—once in daylight and once at night. The satellite's "Day-Night Band" (DNB) of the VIIRS instrument detects light in a range of wavelengths from green to near-infrared, and uses filtering techniques to observe dim signals such as city lights (down to the scale of an isolated highway lamp), wildfires, gas flares, auroras, and reflected moonlight during nighttime hours. In this example [*below*], the satellite acquired a swath of data during nighttime hours over portions of South America, the Atlantic Ocean, and the Eastern United States.



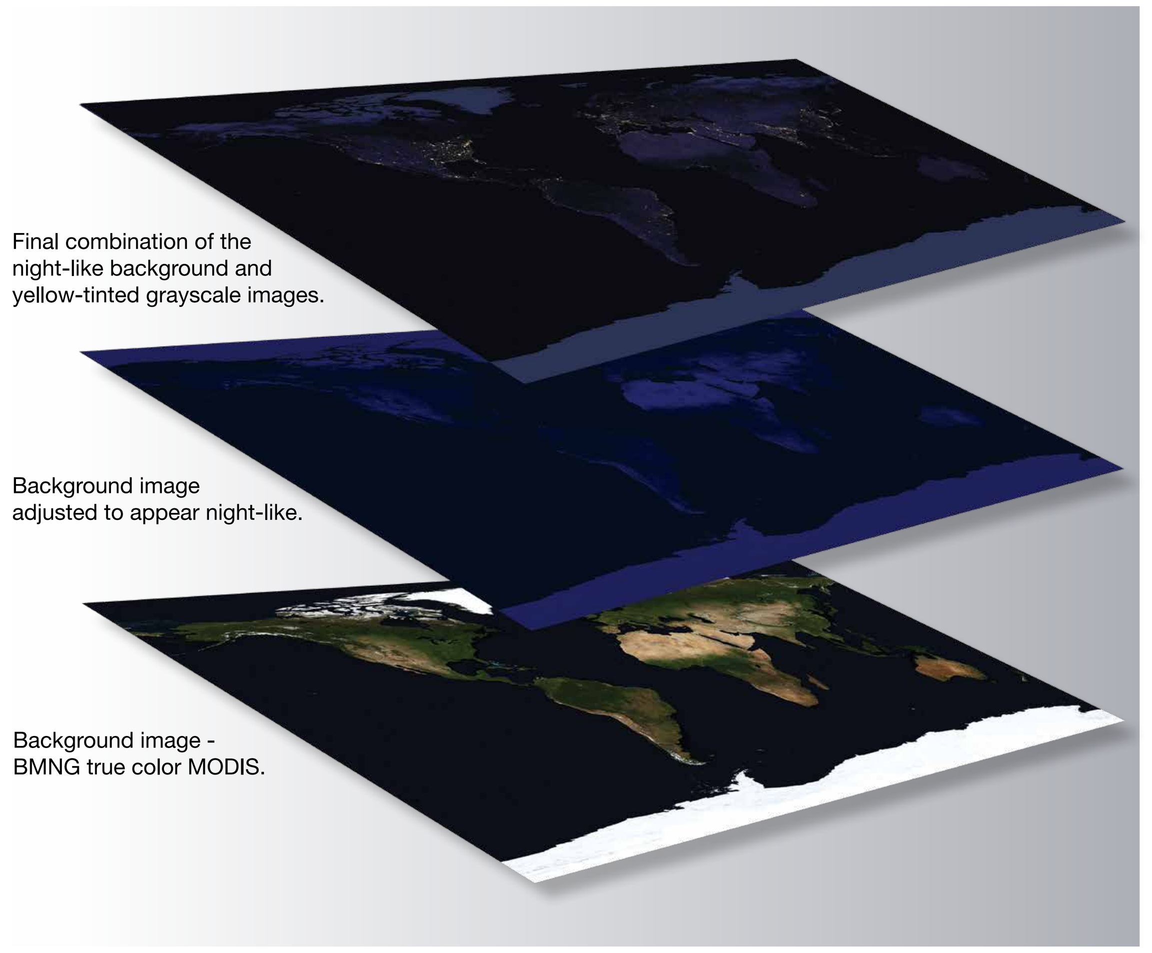
3 Each day, swaths of nighttime data can be stitched together to create an image of the Earth at night. Likewise, swaths of data collected during daylight hours can be stitched together to create a daytime image of Earth each day. Here, three nighttime swaths show lights at night over much of North and South America.



4 Over time, swaths of nighttime VIIRS data are collected and processed to find non-cloudy picture elements, or pixels. All non-cloudy pixels for a particular location were corrected for moonlight, vegetation, and snow, and then averaged to produce this grayscale image [*below*] that depicts the Earth's lights at night, or night lights. Away from the cities, much of the light observed by Suomi NPP during nighttime is from wildfires. In other places, fishing boats, gas flares, oil drilling, or mining operations show up as points of light.

VIIRS grayscale night-lights image.

5 The final step in making the Earth at night image was to combine a background Earth image with the grayscale night-lights image to give context to dark areas. Any background image could have been used—in this case, a global true-color image called the Blue Marble: Next Generation, or BMNG, made with data from the Moderate Resolution Imaging Spectroradiometer (MODIS) was used. The BMNG was then modified to appear more "night-like" to highlight the Earth's land surface. The land appears in shades of dark blue and the ocean appears black. The night-like background and grayscale night-lights images were combined to produce this image of Earth at night; the grayscale night-lights image was tinted yellow to closely match the actual appearance of lights from space.



Final combination of the night-like background and yellow-tinted grayscale images.

Background image adjusted to appear night-like.

Background image - BMNG true color MODIS.

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