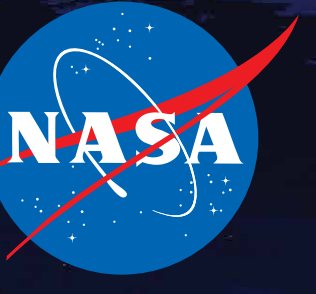


National Aeronautics and
Space Administration



EARTH SCIENCE AT NASA
Earth *at* Night

Earth *at* Night

WHERE DO HUMANS LIVE?

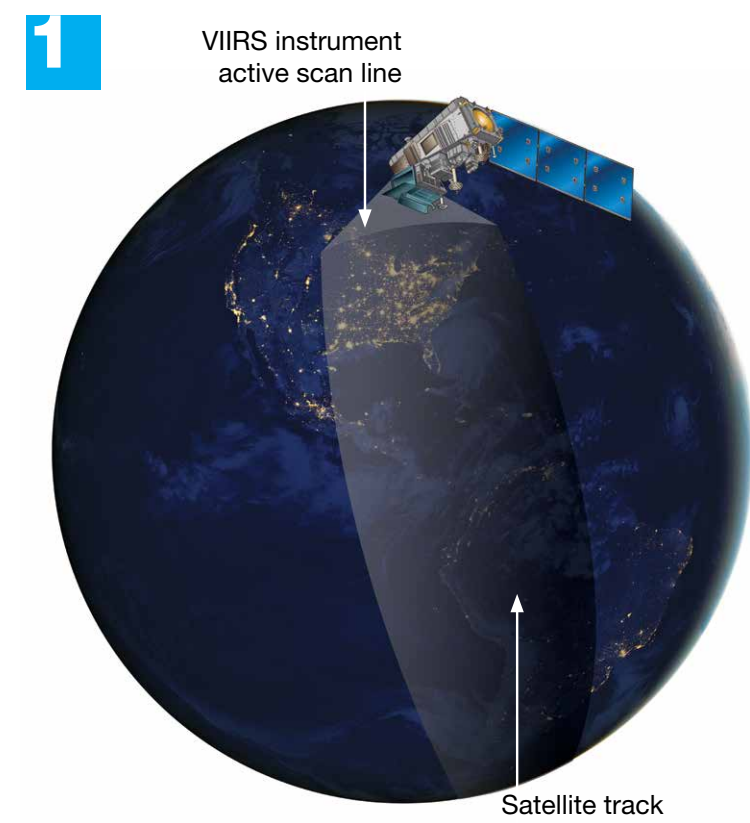
People tend to live where it is easy to make a living, resources are plentiful, the climate is moderate, and the land isn't too rugged. When the United States was settled, early settlements began in the east and gradually moved westward. Could this be the reason the Eastern United States is more densely populated than the west? What if the settlements began in the west and moved eastward instead? How would the United States look today? NASA has been observing and studying Earth since 1958 with aircraft, spacecraft, satellites, and humans. These observations have resulted in millions of images and tremendous amounts of data. NASA Earth observations help geographers worldwide study and answer many questions about human migration and settlement patterns. Where will human settlements be 10 years, 20 years, or even 100 years from now? Can humans build settlements on our moon or other planets like Mars? Will settlements of other planets become a necessity?

One way to study the spatial distribution, or arrangement, of human settlements is to view the planet from space during nighttime hours. The brightest areas are generally the most urbanized but not necessarily the most populated. As you look at the Earth at night, you can see the patterns of distribution. Most major cities are along coastlines, near rivers, or near transportation networks, for example.

ABOUT THIS IMAGE

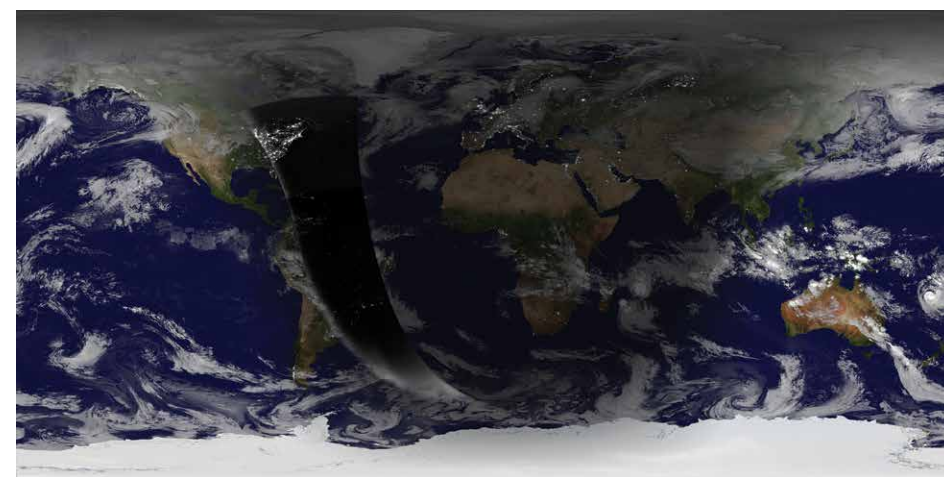
This image of the Earth at night was created with data from the Suomi National Polar-orbiting Partnership (NPP) satellite launched in October 2011 by NASA, the National Oceanic and Atmospheric Administration, and the U.S. Department of Defense. The data were acquired over nine days in April and thirteen days in October 2012. 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 six times better spatial resolution and 250 times better resolution of lighting levels than before.

HOW WAS THE Earth *at* Night IMAGE MADE?

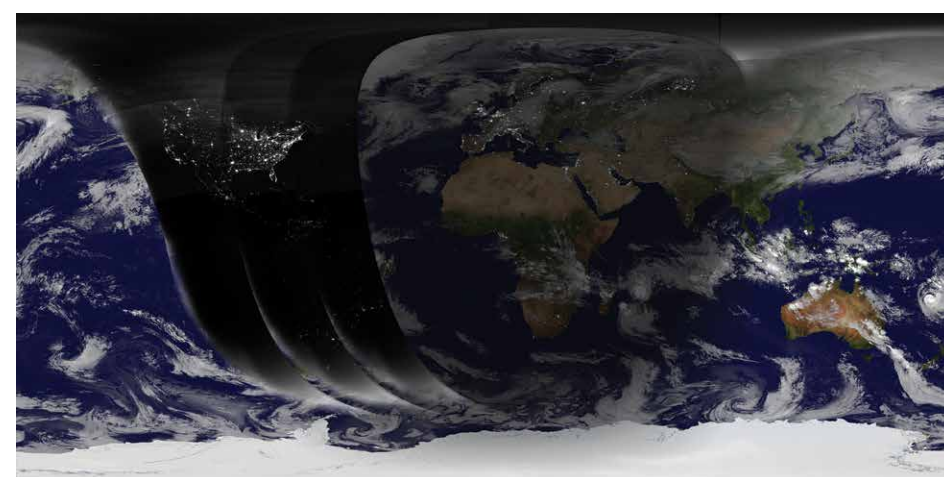


In its orbit, Suomi NPP flies 512 miles (824 kilometers) above the Earth, crossing the Equator at roughly 1:30 AM and 1:30 PM local time while circling the planet from pole to pole and back about 14 times a day. The Visible Infrared Imaging Radiometer Suite (VIIRS) onboard is a multi-spectral scanning 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" 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, the satellite acquired a swath of data during nighttime hours over portions of South America, the Atlantic Ocean, and 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.



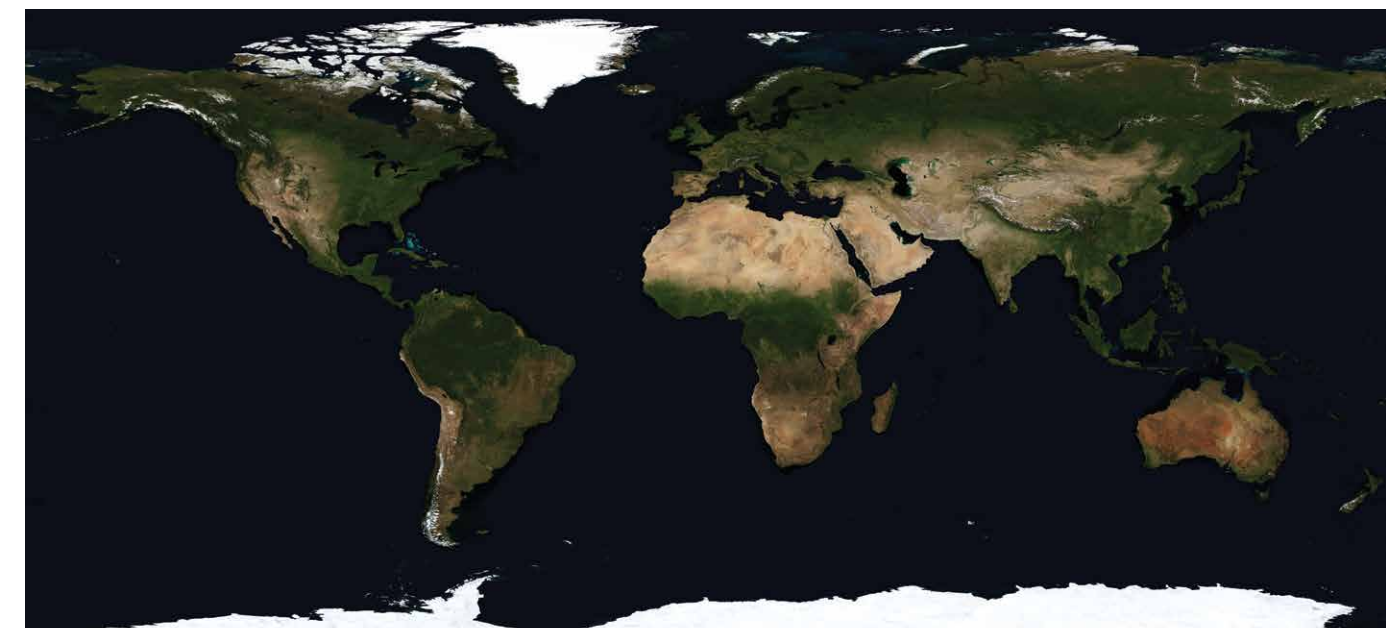
www.nasa.gov

4 Over time, swaths of nighttime VIIRS data are collected and processed to find moonless, non-cloudy picture elements, or *pixels*. All moonless and non-cloudy pixels for a particular location were averaged to produce this *grayscale* image that depicts the Earth's lights at night, or night-lights. It took 312 satellite orbits and 205 terabytes of data to get a clear shot of every parcel of the land surface. Away from the cities, much of the light observed by Suomi NPP during nighttime is from wildfires. In other places, fishing boats, gas flares, lightning, 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.



Background image - BMNG true color MODIS.



Background image adjusted to appear night-like.



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

HOW IS THE VIIRS IMAGE OF THE EARTH AT NIGHT DIFFERENT FROM THE OLS IMAGE?

An earlier, popularized version of the Earth at night was created using data from the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS). It has been a highly successful sensor, but it is dependent on older technology with lower resolution than most scientists would like. Thanks to advancements in sensor technology and improved optics, the VIIRS "day-night band" 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. 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 "day-night band" 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 over-saturating. If the pixel is dark, the signal will be amplified.

The images below show the area surrounding Chicago, Illinois using night-lights data from the OLS onboard the DMSP satellite [*left*], and also from the VIIRS "day-night band" [*right*]. When you look at the two images side by side, the OLS image appears coarse and blurry compared to the high precision VIIRS image that shows greater detail. The improved resolution and improved light-sensor technology of the VIIRS instrument will help weather forecasters, geographers, and scientists alike to "see" better in the dark.



OLS Earth at Night, Chicago, IL

VIIRS Earth at Night, Chicago, IL

HOW IS THE VIIRS EARTH AT NIGHT DATASET USED?

Scientists use the Suomi NPP night-lights mosaic in many research applications. The data are used to characterize atmospheric and surface characteristics, important when studying future settlement patterns and the effects of future population growth. Areas with more lights are usually more economically developed. 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. From the VIIRS data, scientists can study trends by location and examine the economic state of certain regions.

If you live in a city, you know how difficult it is to see stars at night. Light pollution keeps all but the brightest stars from shining through. This light pollution can also be seen from the outskirts of urban areas as a faint glow in the sky. Light pollution affects some more than others. Astronomers rely on clear nights to make observations of the night sky and study Earth's place in the universe. Species of animals that are nocturnal—active mostly at night—can become disoriented by light pollution and change their mating, migration, and feeding habits. Data from VIIRS show changes in sky brightness over time and areas where the negative effects of light pollution are greatest.

DID YOU KNOW?

Paris, France was officially named "La Ville-Lumière," or *The City of Light* in the 1820s when gas street lamps were installed on the avenue of the Champs-Élysées.

Aurora, Illinois officially adopted the nickname *City of Lights* in 1908 after implementing an all electric street lighting system in 1881.

Perth, Australia became known as the *City of Lights* in 1962 when residents lit their house lights and street lights as American astronaut John Glenn passed overhead while orbiting Earth on Friendship 7, and again in 1998 as Glenn passed overhead on the Space Shuttle.

Lyon, France earned the title *Capital of Lights* named for its famous light festival, "Fête des Lumières," which occurs every year on December 8.

The Arabic name for **Medina, Saudi Arabia** means *The Enlightened City*, or *The Radiant City*.

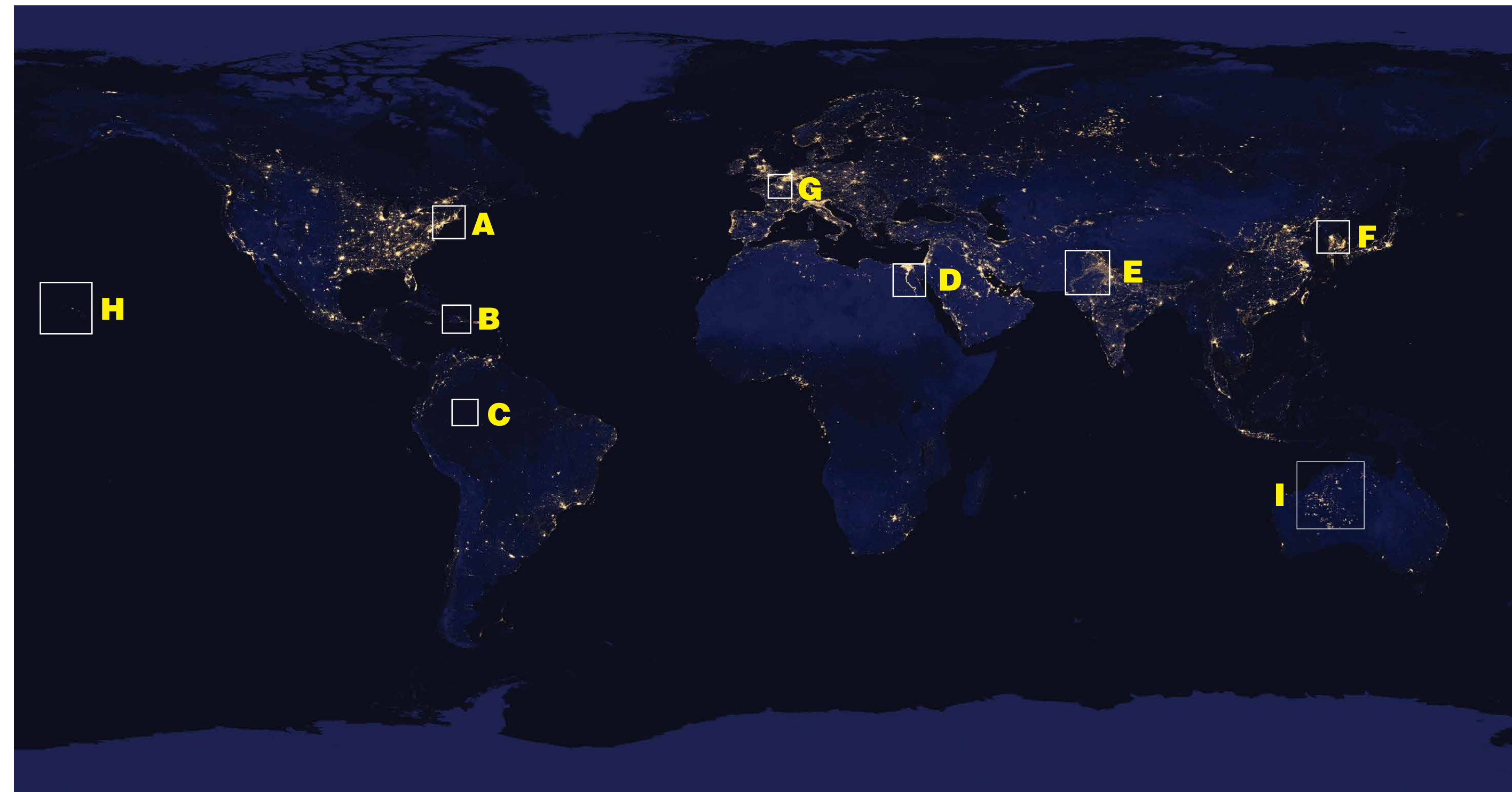
Varanasi, India is also called Kashi, which means *The Luminous One*.

During the war of 1812, **Saint Michaels, Maryland** residents "blacked out" their homes and businesses and hoisted lanterns high in the trees, tricking the British into overshooting the town with their canon fire.

Las Vegas, Nevada is popularly referenced as the brightest city on Earth when viewed from space.

Where IN THE WORLD?

Read each question and fill in the blanks and the corresponding letter of its location on the Earth at Night map. (See answers at bottom of poster.)



1. _____ was originally nicknamed "La Ville-Lumière," or *The City of Light* because it was a center of education and ideas during the Age of Enlightenment and also the first city to install gas street lamps in the early 1820s. Location on map = _____



2. In this region the floodlit, fenced border between _____ and _____ shows up as a faint thin line. North and west of this border, city lights cluster around the Indus River. Location on map = _____



3. Lights from fishing fleets can be seen glowing off the coast of _____. Differences in socio-economic strategies can be seen in the abrupt change in lighting between this country and its neighbor to the north. Location on map = _____



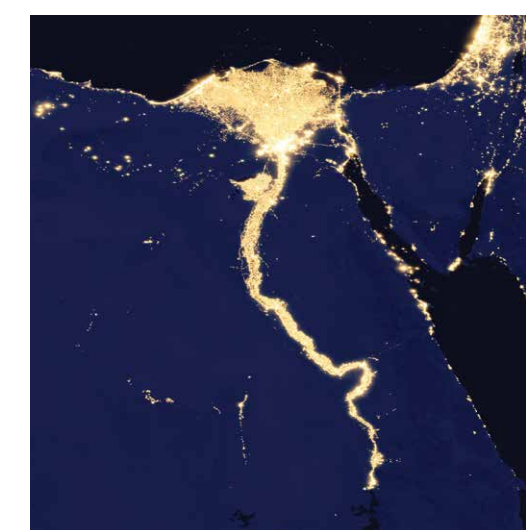
4. One of the brightest areas of the globe is the northeast coast of the _____. In this view, clusters of city lights are strung together by highways that appear as thin, bright threads. Location on map = _____



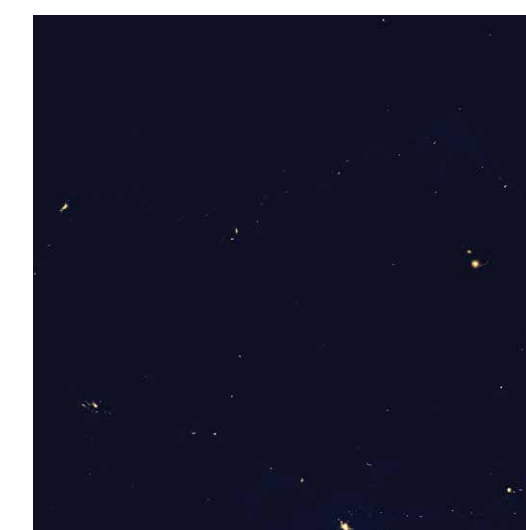
5. _____ and the _____ share the same island known as Hispaniola. Notice the difference in the concentration of lights in these unevenly developed countries. Location on map = _____



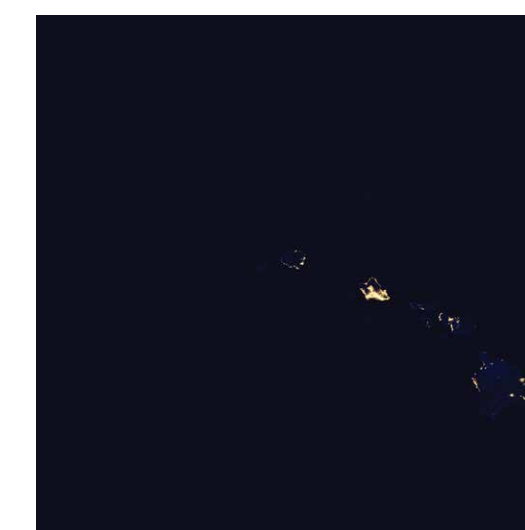
6. The VIIRS instrument onboard Suomi NPP detected several wildfires during different overpass times over Western _____. Location on map = _____



7. The _____ River is the longest river in the world, measuring 4132 miles (6650 kilometers) long. Surrounded by desert, lights abound along the river's valley and spread out across its fan-shaped delta. Location on map = _____



8. Thousands of plant and animal species live in one of the darkest areas on Earth—the _____ rainforest in South America—where only a few light sources are detected. Location on map = _____



9. The state of _____ consists of eight main islands. Oahu, sometimes called "The Gathering Place," is the most populous island and is also the brightest from space, but only the third largest in terms of area. Location on map = _____

WHERE in the WORLD answers

1. Location = G – Paris, France 2. Location = E – Pakistan, India 3. Location = F – South Korea 4. Location = A – United States 5. Location = B – Haiti, Dominican Republic 6. Location = I – Australia 7. Location = D – Nile 8. Location = C – Amazon 9. Location = H – Hawaii