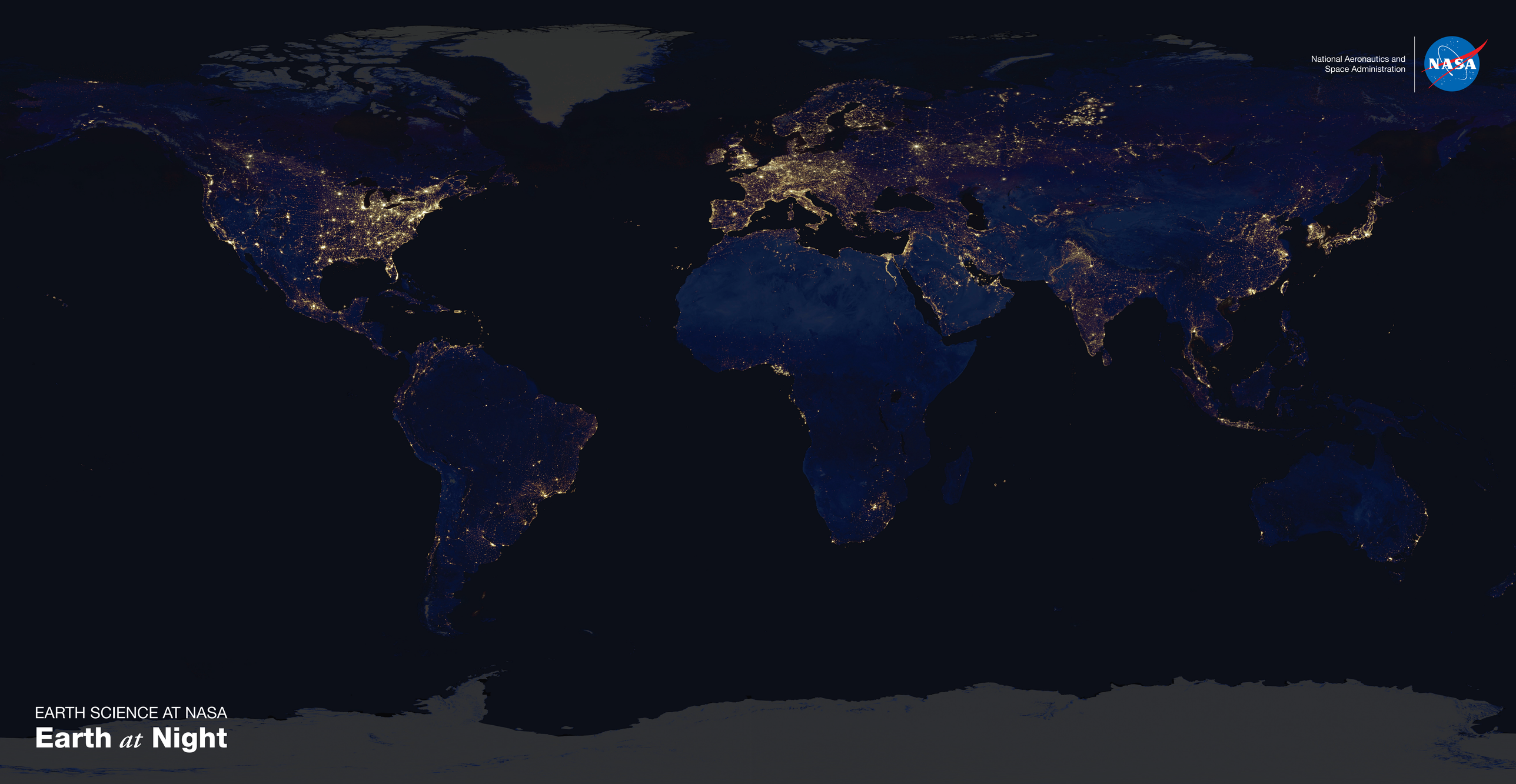

National Aeronautics and
Space Administration
NASA
EARTH SCIENCE AT NASA
Earth at Night

Earth *at* Night

HUMAN SETTLEMENT

Why do you live where you live? Humans have lived on Earth for thousands of years. Throughout history they have chosen particular settlement locations for many practical reasons. But, for just as many reasons, they have packed up and moved to live in different places. Wars have been fought over the right to settle, and natural hazards, like floods, earthquakes, and climate changes, have influenced people to change the locations of their settlements.

NASA has been observing and studying Earth since 1958 with aircraft, spacecraft, satellites, and humans. These observations have generated millions of images and tremendous amounts of data. NASA Earth observations help geographers worldwide to 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 other worlds like Mars or our moon? Will settlements of other planets become a necessity?

WHERE ARE HUMAN SETTLEMENTS?

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. Cities, highways, roads, agricultural areas, industrial regions, and transportation hubs around the world are all large scale evidence of the build up of human systems.

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?

ABOUT THIS IMAGE

This image of Earth's city lights at night shows the *spatial distribution*, or arrangement, of human settlements. White areas of light show urbanized areas where population is typically large. As you look at the image, you can see the pattern of this distribution. Cities are along coastlines and transportation networks.

This image of Earth's city lights was created with data from the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS). The OLS sensor orbits Earth, acquiring one swath, or area, of data at a time. The swaths are processed to find non-cloudy picture elements, or pixels, for short. Over the course of a year, all non-cloudy pixels for a particular location on Earth are averaged to produce a global grayscale image. The color image you see on this poster is created by combining the grayscale DMSP image with a version of the Blue Marble: Next Generation (BMNG) image that is modified to appear more "night-like". (For a more detailed explanation see section to the far right entitled: *How was the Earth at Night image made*)

IMAGE CREDITS

DMSP data – U.S. Air Force Weather Agency; DMSP data processing – NOAA's National Geophysical Data Center; DMSP and MODIS image composite – NASA.

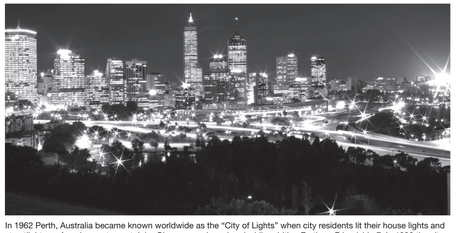
HOW IS THE DMSP GLOBAL DATA SET USED?

Scientists use the DMSP OLS night lights mosaic in many research applications. Often the night lights data are used in place of other data sets that do not have global coverage. Global data are important when studying future settlement patterns and the effects of future population growth.

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 at night mostly—become disoriented by light pollution and change their mating, migration, and feeding habits. The DMSP data show changes in sky brightness over time and areas where the negative effects of light pollution are greatest.

Once sources of light like fire and lightning are removed from the DMSP data, the remaining *stable* lights are those that are electric from streetlights, headlights, store signs, etc. Areas with more of these 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 also show how far urban sprawl extends and areas where growth is occurring or has not yet occurred. Urbanization and population *density*—the number of items in a defined area—are tied to one another and can be studied from the night lights mosaic. 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 DMSP data, scientists can map population, study trends by location, and examine the economic state of certain regions.



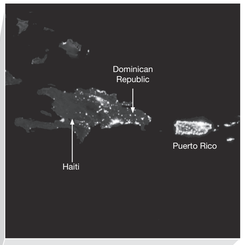
In 1962 Perth, Australia became known worldwide as the "City of Lights" when city residents lit their house lights and streetlights as American astronaut John Glenn passed overhead while orbiting Earth on Friendship 7. In 1998 the city repeated its feat as Glenn passed overhead on the Space Shuttle. Photo credit: Autumn Leaf.

www.nasa.gov

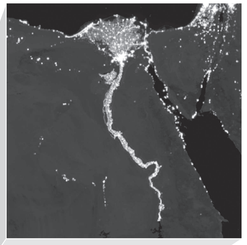
WHAT CAN BE SEEN IN THE Earth *at* Night IMAGE?

One of the brightest areas of the globe is the northeast coast of the United States. In this view, city lights stretching from Boston, Massachusetts to Norfolk, Virginia are strung together by highways that appear as thin, bright threads.

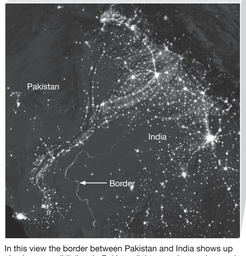
The Dominican Republic and Haiti share the same island known as Hispaniola. Notice the difference in the concentration of lights in each of these countries. To the east is the island of Puerto Rico, which is smaller yet has more lights.



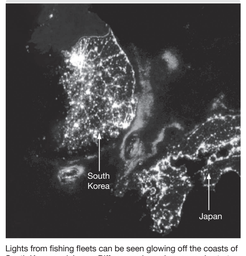
Lights surrounding the Nile River can be seen snaking from the Aswan Dam to the Mediterranean Sea, ending in a fan shape at the river's delta.



One of the darkest areas of the globe is the Amazon Rainforest in Brazil—which is almost entirely dark—but lights are beginning to appear in the region.



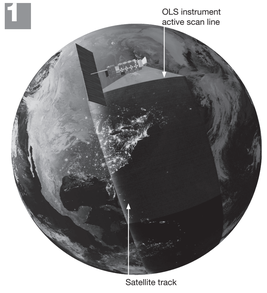
In this view the border between Pakistan and India shows up clearly as a well lit line. In Pakistan lights are clustered around the Indus River and its tributaries—the rivers are distinguishable by the lack of light, and appear as thin dark lines.



Lights from fishing fleets can be seen glowing off the coasts of South Korea and Japan. Differences in socio-economic strategies can be seen in the abrupt change in lighting between North Korea and South Korea at the top of the image.

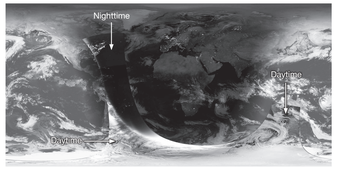
HOW WAS THE Earth *at* Night IMAGE MADE?

1



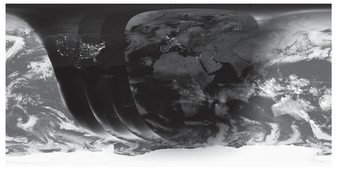
This visualization shows the DMSP F16 satellite in *day/night* sun-synchronous orbit on January 30, 2008, at about 8:00 PM local time. As the satellite moves along its orbit, the OLS instrument is depicted scanning the area below. The visible wavelength data it acquires are shown along the track of the satellite. On this non-moonlit night clouds are not visible, but city lights are.

2 The image was then re-projected to a flat map to show a global view of the OLS visible data. It shows the data from about one half of an orbit. The day/night orbit means that about half the orbit occurs during daytime and half during nighttime. The satellite passed over the Atlantic during nighttime and over the Pacific during the day.



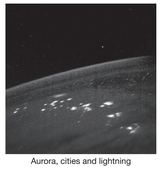
3 The DMSP satellite orbits the Earth about 15 times per day. Every day of the year, a global gridded data set of the nighttime data is created. Here three orbits have been processed to remove the daytime parts and then re-projected to the same global map. The process was repeated for all orbits from one day.

The global data set for any particular day will have gaps for the regions of the globe that are experiencing daylight. For this day, January 30, 2008—which occurred during Northern Hemisphere winter—the South Pole was fully illuminated and no nighttime data could be collected there.

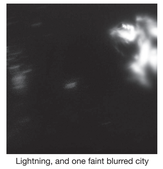


4 The yearly DMSP global images are processed to identify and remove pixels containing clouds, aurora, fires, lightning and other transient sources of light. The following set of photos taken from the International Space Station (ISS) show some sources of light that are visible from orbit. ISS photos have a much higher resolution than DMSP imagery, but many of the same phenomena can be seen in both. Photo credit: NASA.

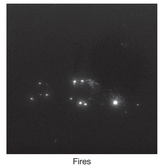
Moon, aurora and cities below



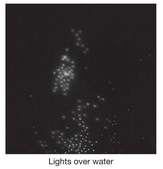
Aurora, cities and lightning



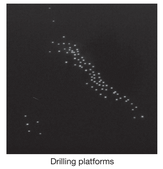
Lightning, and one faint blurred city



Fires



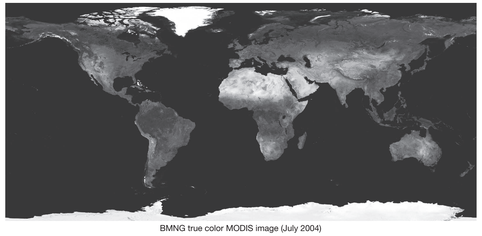
Lights over water



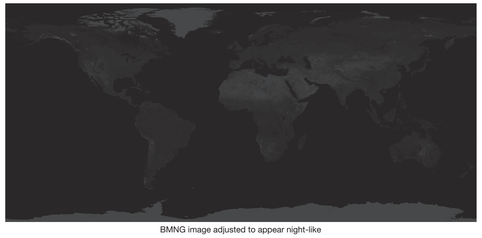
Drilling platforms

5 After a year's worth of daily global data sets are created, further processing locates pixels that have stable lights, i.e., pixels that are bright on most nights of the year. The result is the DMSP Nighttime Lights data set available at *http://www.ngdc.noaa.gov/dmsp/global_composites_v2.html*.

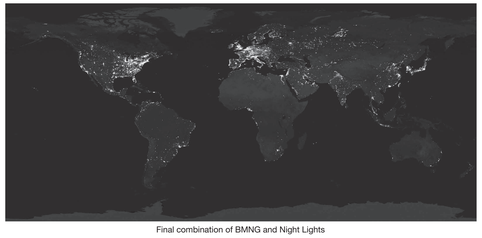
6 The final step in making the night lights image was to add a background Earth image to give context to dark areas. Any background image could have been used—in this case the BMNG true-color MODIS image was used. BMNG shows Earth during daytime, so the colors and brightness of the image were adjusted in Adobe Photoshop to give the impression of nighttime. Next the DMSP OLS night lights image was overlaid and registered to the background image; and since the night lights are grayscale, they were tinted yellow to more closely match the actual appearance of the frequently used sodium vapor lights.



BMNG true color MODIS image (July 2004)



BMNG image adjusted to appear night-like



Final combination of BMNG and Night Lights

LINKS

NOAA National Geophysical Data Center: *www.ngdc.noaa.gov/dmsp/dmsp.html*
NASA Earth Observation System Project Science Office: *eospso.gsfc.nasa.gov/*
NASA Gateway to Astronaut Photography of Earth: *earth.jsc.nasa.gov/*

EW-2009-8-033-GSFC