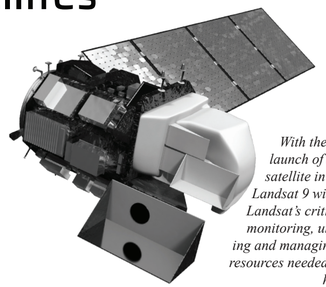
Observing Earth since 1972 with Landsat Satellites

Remote sensing enables studying Earth from so many perspectives. A combination of science and engineering has promoted our knowledge about how our planet's system functions. Satellite sensors, like those on the Landsat platforms, complement earth-based sensors. Geoscience disciplines like geophysics, oceanography, and geology are only a few of so many areas of study for which Landsat provides reliable information.

Since the first Landsat satellite was launched in 1972, the mission has become an indispensable part of our national infrastructure, providing a decades-long, unique and invaluable record of our changing landscapes—with many practical uses for our lives and livelihoods.

Free Data
The series of Landsat satellites, which will continue with Landsat 9, has collected reliable, consistent, and objective observations of the global land surface for nearly 50 years. The U.S. Geological Survey (USGS) maintains an archive of Landsat images. In 2008 the USGS opened the archive to the public allowing anyone to search, browse and download more than 8 million images online for free.

The Power of a Pixel
Landsat provides valuable information by measuring reflected and emitted light energy in both visible and infrared portions of the spectrum.



With the upcoming launch of the newest satellite in the series, Landsat 9 will continue Landsat's critical role in monitoring, understanding and managing the land resources needed to sustain human life.

This information, taken over an area that is 30 meters by 30 meters, is recorded digitally as a pixel. Landsat pixels are about the size of a baseball diamond. Pixel-by-pixel, Landsat images of the landscape are built up to provide data at the scale necessary to effectively manage our lands, our cities, and our natural resources over time.

The Just-Right Satellite
Land cover and land use around the globe are changing faster than ever before. This has sweeping consequences. Landsat collects data at the scale of human interactions with the land and with the frequency necessary to detect, monitor and understand changes in land use and land cover. Managing our land and water resources in a sustainable way is important for life on Earth—and if you want to manage something well, you need to be able to map it well.

Sharing our Understanding and Engaging with Geosciences through Landsat and Earth Observations

Geoscience is for everyone everywhere
Geoscientists study all aspects of Earth: the lithosphere, atmosphere, hydrosphere, cryosphere, and the biosphere—where all spheres interact. Everyone can relate to and observe the Earth around us with one of our several senses. Earth observation satellites like Landsat extend our senses to help us monitor our changing and beautiful planet as it affects our everyday lives.

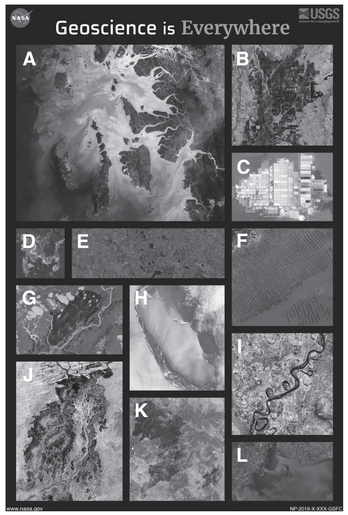
A Vision for Earth Observation
Fifty-three years ago, Secretary of the Interior Stewart Udall announced his vision to create "a program aimed at gathering facts about the natural resources of the Earth from Earth-orbiting satellites." Since 1972, the Landsat series of satellites has been keeping a watchful eye over our planet. Landsat's continuous 47-year accumulation of imagery has provided stunning images of the Earth and enabled geoscientists globally to document our changing landscapes.

An Unrivaled Resource
Landsat's high-quality scientific data are routinely used for water, fire, food and carbon management across the globe and Landsat data serve as the base for Google Maps and make Earth Engine's time-lapse app possible. Modern analytical and computing capabilities have enabled data users to harness Landsat's extensive record of changing land cover conditions. This data record provides an unrivaled resource for geoscience applications over a timescale of decades.

Access is for everyone
Landsat data is a base for mapping applications and some geospatial analysis on multiple platforms with a wide range of simple to sophisticated tools. Anyone with a smartphone can view imagery of his or her location. Data users can overlay a route on an image base. Citizen science apps allow everyone to make image-based Earth observations; to capture the state of a local or far-off environment, and see how it changes over time, whether that's a month or nearly half a century.

Benefits to Society
Landsat data, used in combination with today's advanced geographic information systems, image processing software, and cloud computing, enable individual users and research teams to process as many scenes as needed for Earth analysis. Many archived images of a single site can now be easily obtained and analyzed for land-surface change over time. Analysis Ready Data (ARD) delivers a time-layered datacube of imagery adjusted to a common reflectance model. This allows a user to see land-cover or land-use conditions over time and across an entire area of interest, such as natural resource management, agriculture, disaster management (e.g., wildfire, floods, drought), industry, forestry, human health, climate, energy, urban growth, and ecosystems and biodiversity. All these fields offer geo-careers that can serve society.

Geoscience from Space



A. Mergui Archipelago
The Mergui Archipelago in the Andaman Sea, on the eastern side of the Indian Ocean, is a sparsely-inhabited set of over 800 islands. Many are surrounded by coral reefs and tourism is a major industry, with divers from around the world visiting to enjoy the high diversity of plant and animal life. Landsat 5 imagery shows sediments entering the ocean from the land and spreading out between the islands. Oceanographers are monitoring onshore expansion including deforestation and agriculture development, which can produce harmful algal blooms as sediment plumes that can damage coral reefs.

B. Wetland Ecology in the Sacramento River Valley
Every year, migratory birds travel thousands of miles from their winter habitats to their summer breeding grounds. The most extreme is the Arctic Tern, who travels from Antarctica to the Arctic and back every year totaling 12,000 miles. These yearly migrations can be dangerous and a key component to their survival during this trek are wetlands. A wetland is an ecosystem that is covered by water and contains vegetation and aquatic plants, providing food and shelter. An area in the Sacramento River Valley of California, where rice is grown, provides just that. This area is dominated by agriculture, shown by the square fields captured in this Landsat 8 image from December 2018. Growing rice requires a lot of water, every summer these rice fields are flooded (blue areas). This creates ideal habitat for birds that are passing-through, giving them a higher chance of a successful migration. Scientists, natural resource managers, conservationists, and the agriculture industry all use remote sensing and GIS to track and monitor bird migrations, water and habitat availability, and the progress of the growing season.

C. Lithium Ponds in Chile
We live in an electronic age, where batteries seem to be a necessity for daily life. Ever wonder where the stuff that makes a battery work comes from? The Landsat 8 satellite captured evaporation ponds in Chile in November 2018, where lithium is being processed for use. Lithium is a chemical that is a key ingredient in rechargeable batteries and is widely used for electric vehicles, laptops, cell phones, and other gadgets. Lithium is naturally found underground in this Chilean desert; a saltwater solution is pumped out of the ground and into these ponds. Over time, the sun and wind will evaporate the water, leaving the lithium and other salts behind. The different colors of the ponds are caused by different concentrations of lithium and other salts that are in the water. Ponds with the lighter blue colors contain higher concentrations of lithium. Lithium mines consume water from sources that also provide water to other users, including indigenous residents and copper mines. If the demand for lithium continues to increase, this could lead to problems of adequate water supply.

D. Brazilian Mine
An image of the largest of the mines of Brazil's Carajás Mountains (Serra dos Carajás) called the Serra Norte complex. The terraced appearance is a result of the open pit mining method, in which layers are excavated one at a time. According to a 2013 study, mining at four of Serra Norte's main pits had produced 1.2 billion tons of high-grade iron ore. In a scene acquired by Landsat 8 on July 16, 2018, the red-brown earth contrasts starkly with the greens of the surrounding Carajás National Forest. Most of the metallic mineral deposits in the Carajás Mountains are found in areas of rock that date back to the earliest part of Earth's history. Scientists have been working to better assess how mining affects deforestation of the Amazon—the world's largest remaining tropical forest—as mineral production has increasing value to Brazil's economy.

E. South Dakota Hail Damage
On June 22, 2017, an early-morning storm system traveled through central and eastern South Dakota and into southwest Minnesota, leaving a trail of destruction from wind and hail in its wake. One of the hardest hit areas was Castlewood, South Dakota, which experienced wind gusts as high as 90 mph (140 km/hr) and golf-ball-sized hail. In Castlewood, hail broke windows and punched holes in the siding of homes. Surrounding farmland had severely damaged crops. The damage to crops is evident in this false-color image of the Castlewood area (upper left portion of the image) and areas to the east and south. Hues of red in this image indicate healthy, growing vegetation, while the white swath trending northwest to southeast shows the hail-damaged cropland. The Operational Land Imager aboard Landsat 8 captured this image on July 7, 2017, fifteen days after the destructive storm. Imagery such as this is used by farmers as well as federal and private insurance agencies to document the extent and severity of crop damage.

F. Aquaculture in Sansha Bay
Aquaculture is sea-life farming. China accounts for nearly two-thirds of the world's aquaculture and its fish farmers have been refining their food production processes since before 500 BC. Sansha Bay, in southeastern China, has become one of the world's most productive and dense sites for raising yellow croakers primarily and some abalone, especially around Qingshan Island. Nearly two decades ago, before China's seafood-management commitment, this croaker species was nearly fished to extinction. In the Landsat 8 image collected on April 8, 2017, the lighter areas of objects near the shore are cages and the darker areas are algae culture growing along underwater ropes, analogous to fenced fields and feed for livestock on land. Marine biologists, food production researchers, and farm managers are in demand around the world to address significant food provision challenges that aquaculture addresses.

G. Fire and Ice in Siberia
Between frozen land, lakes, and rivers in Siberia, multiple fires burned (orange and red areas) and created smoke plumes that were visible from space. Images captured from the Landsat 8 satellite in April 2019 allow wildland fire agencies and first responders to see through the smoke to monitor the perimeter of the fire in order to protect life and property. Using satellite imagery for fire detection also allows response agencies to identify new fires early, before they become large and uncontrollable. You can also see a burn scar in this image between the frozen lakes and the river. This is an area that has previously burned, resulting in the black ground. This information is used by scientists who study wildfire behavior and post-fire plant succession. Emergency responders use the imagery to determine where and when to deploy ground-based firefighters and to monitor the progression of the fires to keep people safe.

H. Larsen C Ice Shelf
The Landsat 8 satellite has a thermal infrared sensor that allows scientists to derive the temperature of objects. This image from September 2017 shows the thermal pattern of an iceberg in Antarctica that broke off from the Larsen C ice shelf. Thermal imagery has the advantage of showing the different temperatures of the ice, which indicate differences in the thickness of ice types. Thicker ice has a colder signal (white and light blue) and thinner ice has a warmer signal (pink and yellow). Scientists use this information to study how the ice is changing due to warmer temperatures, ocean currents, and storm surges. In recent years however, the ice has not been as strong (thick) and is causing problems for penguins that rely on the ice for breeding.

I. Mississippi Flood
Intense storms during the period of February 22-24, 2019, caused major flooding along the Middle Mississippi River. The extent of the flooding along the stretch of the river from Memphis, Tennessee (top), to Tunica, Arkansas (bottom) – an "as-the-crow-flies" distance of approximately 50 miles - is very evident on this false-color image acquired on February 25, 2019, by the Operational Land Imager on Landsat 8. Other flooded areas on the image include Arkabutla Lake, a reservoir on the Coldwater River (bottom right), and the Phillips Bayou (center left). On the image, flood waters appear blue, vegetation is green, and bare ground is brown. The information contained in this image is useful to hydrologists, planners, insurance companies, and disaster relief agencies and organizations for documenting flooded areas, assessing damage, and preparing for future flooding that will likely occur due to already saturated soils, additional rainfall and upstream snowmelt.

J. Niger Delta
The inland delta of the Niger River provides fisheries, pasture, and agricultural resources for over 1 million people in Africa. The inland delta is shown in vibrant shades of green surrounded by the arid tan landscape south of the Sahara Desert on this Landsat 8 image. The area is flooded seasonally from September to December, as rainfall from the tropical headwaters region enters the delta. The delta provides a biodiverse habitat for migrating birds and hosts multiple indigenous and endangered species of plants and animals. Water resource managers and ecosystem scientists are monitoring threats to the region including expansion of irrigation projects upstream, and decreasing rainfall patterns. Landsat imagery can enable prediction of low flow conditions that impact ecosystems, fisheries, grazing, and agriculture, as well as high water conditions leading to flooding that damages habitats and agriculture.

K. Rockhouse Fire in Texas
In the spring and summer of 2011, following more than a year of statewide drought conditions, Texas was suffering from hundreds of wildfires. The Rockhouse Fire burned through more than 300,000 acres in the Davis Mountains and adjacent regions of west Texas over an almost one-month period. Dozens of homes were destroyed in Ft. Davis, along with surrounding pastures and forested lands including parts of Davis Mountain State Park. In this Landsat 5 image, the burned area is varying shades of red, with the darkest being the most intensely burned. Unburned vegetation is green. Forestry scientists use images such as this Landsat 5 image to determine fire burn intensity, which affects restoration efforts. Geoscientists use such images to predict the potential for landslides.

L. Lake Erie Algal Bloom
Algal blooms can produce toxins that may harm both wildlife and humans. The turquoise-colored bloom shown here in a Landsat 8 image began to form in July of 2017, and by August had spread across most of Lake Erie. Algal blooms can be directly related to extra nutrients in the form of nitrogen and phosphorus entering the lake in agricultural runoff, industrial pollution, and sewage. Landsat imagery has been used for decades to monitor algal blooms in fresh and ocean waters, allowing scientists to predict the occurrence of these blooms and to assess the risks from such occurrences. Remote sensing allows water resource managers worldwide to monitor water quality by identifying pollution, tracking drought, and detecting the impact of landcover change, enabling informed decisions about managing limited water resources.

NW-2019-5-371-GSFC

A Nationwide Consortium

What is AmericaView?
AmericaView is a nationwide, university-based, and state- implemented consortium advancing the widespread use of remote-sensing data and technology through education and outreach, workforce development, applied research, and technology transfer to the public and private sectors.

What does AmericaView do?

Strengthens the geospatial skills of the current workforce
- Prepares qualified employees for the high-growth geospatial sector
- Provides education for underrepresented groups in the geospatial field

Inspires and prepares the next generation of scientists
- Provides curriculum materials to strengthen Science, Technology, Engineering, Art and Mathematics (STEAM) education in K-12+ classrooms
- Assists teachers in meeting national and state educational standards for STEAM education

Facilitates access to remote sensing imagery, data, applications, and information
- Reaches out to local and national end-users such as decision makers, land-use planners, agriculture producers, water-quality specialists, natural-resource managers, researchers, teachers, and students
- Provides current remotely sensed data and its analysis, assisting first responders to save lives and property and offering GIS and mapping support for regional post-disaster recovery efforts

Conducts applied research for natural resource management
- Improves understanding of water availability and quality issues
- Identifies agricultural challenges and opportunities

What is Earth Observation Day?

Earth Observation Day (EOD) is a STEAM outreach event sponsored by AmericaView to celebrate the Landsat mission, a joint effort of the U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA).

EOD introduces students to geography and Earth observations in a stimulating and dynamic way using the tools and technology of geospatial science. Enjoy the beauty of Earth captured by satellite and explore images used to solve some of Earth's most perplexing issues. Imagine pictures of the world's geography at your fingertips. EOD also highlights potential careers in geospatial technology. The EOD web site (www.americaview.org/earth-observation-day) provides information on how to engage students in the use and analysis of free remote sensing imagery with satellite posters of states, free geospatial software exercises, and additional materials and interactive games.

Resources for Educators

Landsat resources at NASA: https://landsat.gsfc.nasa.gov/
Landsat resources at USGS: https://www.usgs.gov/land-resources/nli/landsat
AmericaView education resources: https://www.americaview.org/resources
Geospatial science lessons: https://www.americaview.org/earth-observation-day
NASA's Earth Observatory: https://earthobservatory.nasa.gov