Landsat satellite looks back at El Paso, forward to a new mission

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Landsat has seen a lot in its day. In one spot of desert, where the Rio Grande marks the border between the United States and Mexico, the satellite program captured hundreds of images of fields turning green with the season, new developments expanding from El Paso, Texas, and clouds moving over the neighboring mountains.

For more than 40 years, Landsat satellites have collected millions of images of this region and others worldwide. And as Landsat 8 begins its new mission, collecting more than 400 images per day, scientists are anticipating what the program's trove of images will reveal about Earth's surface.

"These are scientific data, as much as they're beautiful images," said Doug Morton, a physical scientist at NASA's Goddard Space Flight Center in Greenbelt, Md., who uses Landsat data to study changes in forest ecosystems over time.

Orbiting 438 miles above Earth, Landsat satellites collect visible and infrared light reflected from the surface and thermal infrared light emitted by the surface. The different wavelengths can provide information not just about visible elements of the land cover, but also about the health of vegetation, water use and more.

Transparencies and crayons

When the first Landsat satellite, originally called the Earth Resources Technology Satellite, or ERTS, started orbiting in 1972, it was no small feat to visualize the data and conduct research.

"When ERTS was first launched, there was one cathode ray tube in the country that could take in the digital data and display an image," said Jeff Masek, Landsat project scientist at Goddard.

In the early years, satellite observations of the light reflected off of Earth were transmitted down to receiving stations and mailed to processing centers. Computers translated the image data into photographic prints or transparencies that could be placed on light tables for interpretation. Alternatively, computers translated the numbers in each pixel into alpha-numeric symbols that were printed on large reams of paper. Analysts, often graduate students, could then color-in the symbols with crayon or magic markers. Standing on ladders over the colored-in data, they'd try to visualize the landscape represented by the maps.

"Things were pretty primitive in those days," Masek said. "People say, 'Well why didn't they produce a global land cover map in those first few years?' They were lucky to be able to look at one image for a Ph.D. dissertation."

The process is significantly quicker with Landsat 8, a joint mission between NASA and the U.S. Geological Survey, or USGS, which took operational control of the satellite May 30.

NASA and USGS scientists have been working for months to properly calibrate each of the thousands of detectors on Landsat 8, so scientists using the data can access images that are accurate and consistent with previous Landsat missions. The latest satellite will collect at least 400 images per day, and the USGS facility in Sioux Falls, S.D., will receive, process and archive those scenes within 24 hours. Scientists, analysts and

the general public will have access to these images within hours, as the USGS distributes requested digital images over the internet for free.

Millions of scenes, free to explore

Since 2008, all Landsat digital images in the USGS archive have been freely available online. Scientists, land managers, planners and others have downloaded scenes more than 11 million times.

Researchers have been studying scientific information from Landsat for decades now, Morton said. Landsat data are the backbone for a range of research and operational programs, including monitoring agricultural productivity, water use and forest fire damages in the United States. But opening the Landsat archive, combined with modern computing power, allows scientists to take a wider view than just one scene, and to look over time.

"The ability to use every image in the archive has revolutionized the way we do science, conduct business and share information worldwide," Morton said. "Instead of picking an anniversary date – like the middle of summer – and looking at that date over as many years as there are cloud-free data available, we're starting to mine every pixel in the archive."

Due to cost and computing restrictions, a scientist studying deforestation, for example, previously might have only used two images – one before and one after – to see the extent of logging. Now, with free images and powerful computers, researchers can assemble dozens of monthly or seasonal images to examine the ebb or flow of cutting and regrowth.

"There's been a proliferation of very large-scale applications of the scientific analysis we know how to do," Morton said. "The range of Landsat data uses continues to grow, and our planet is constantly

changing. That's the exciting part about Landsat 8 – the continuity of observations and the next chapter in the story of our changing planet."

While the methods for analyzing data have vastly improved in the last 40 years, the reasons for collecting data have remained constant, said Bruce Cook, Landsat deputy project scientist at Goddard.

"It's still inventorying natural resources, still looking at their utilization," Cook said. "It's still looking at the interactions between people and their environment. But now you're talking about a world population that has doubled, almost, since the first Landsat. So there's even more pressure on our natural resources, and more reason to be studying these things."

Building a complete record

The USGS Sioux Falls Landsat archive already stores more than 3 million scenes. But it could take millions of images—and billions of pixels—to get a complete record of issues like how ecosystems are responding to a warming world, Masek said.

"There are a bunch of interesting ecological questions related to climate change, which Landsat could be applied to," he said. "But that takes a lot of data. You don't get a reliable answer if you just look at a couple of images. You really have to look at a deep-time series."

He and Morton have studied a strip of land in Quebec, Canada, to measure shrub density, for example, and found that some areas are getting greener as more plants sprout in areas that were previously too cold. Others have used Landsat to scour Siberia and study how permafrost thaws affect the number of lakes, Masek said.

"I'm very interested in, now that we have a 40-, going on 50-year record, the signs of climate change in ecosystems around the world," he said.

Researchers can also make full use of all of the different wavelengths, Morton said. Natural color images like the El Paso animation are created from wavelengths within the range of human vision. But Landsat 8's Operational Land Imager detects a total of nine spectral bands, including four infrared wavelengths beyond what people can see. Scientists use different combinations of bands to measure the health of the vegetation on the ground, watch young forests grow and perhaps change in species composition. Landsat data are also used to study the atmosphere: For example, a time series can help researchers study the reduction of sulfur dioxide pollution over Pennsylvania and the eastern United States after the shuttering of Midwestern coal plants.

"A scientist, looking at these images, sees more than initially meets the eye," Morton said. "The information in different Landsat bands allows scientists to quantify subtle changes over time—the response of a forest to droughts, the change in reflectance as a forest canopy grows taller and more variable over time. We see that ecosystems are changing all the time, and Landsat data captures these changes like no other program in the world."

Over Landsat's 40 years, scientists have made significant strides in understanding, evaluating and interpreting the data that comes back from the program's satellites, Morton said. With the new computer power and the continuously growing archive, scientists can take a closer, more informed look at the planet.

"History is made every day," he said. "You better have an image to capture it."

More information: www.nasa.gov/landsat

Provided by NASA's Goddard Space Flight Center