Landsat at 45: how it changed the way we see the Earth

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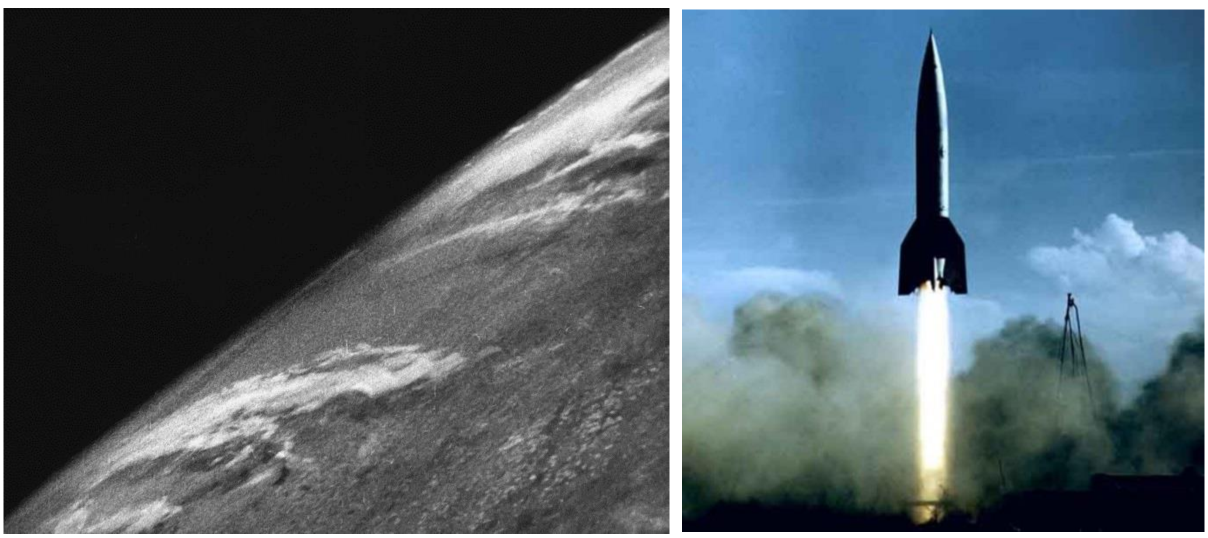
Introduction

Yogi Berra once said: "You can observe a lot by just looking."

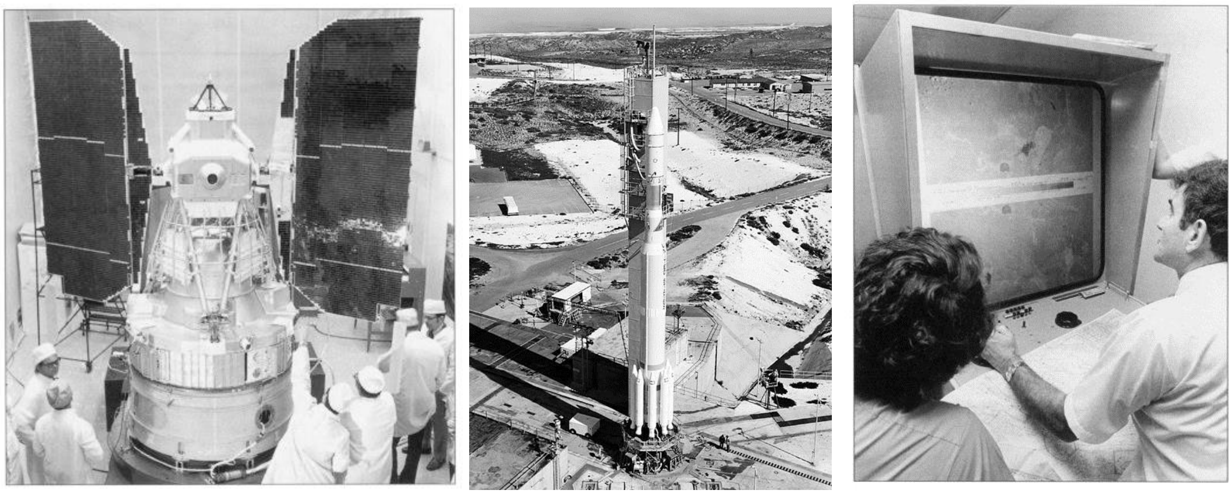
On October 24, 1946, more than 10 years before the launch of the first artificial satellite Sputnik, scientists at the White Sands Missile Range in New Mexico placed a camera on top of a captured German V-2 ballistic missile. As the rocket flew to an altitude of about 65 miles - just above the generally recognized border of outer space - the 35-millimeter motion picture camera snapped a frame every one and a half seconds. Minutes later, the missile came crashing back down and slammed into the ground at more than 340 mph, but the film survived and gave us our first glimpse of Earth from space.



First image of Earth taken from space (left) and a V2 missile launch (right), similar to the one that was used to take the image. Courtesy of White Sands Missile Range/Applied Physics Laboratory.

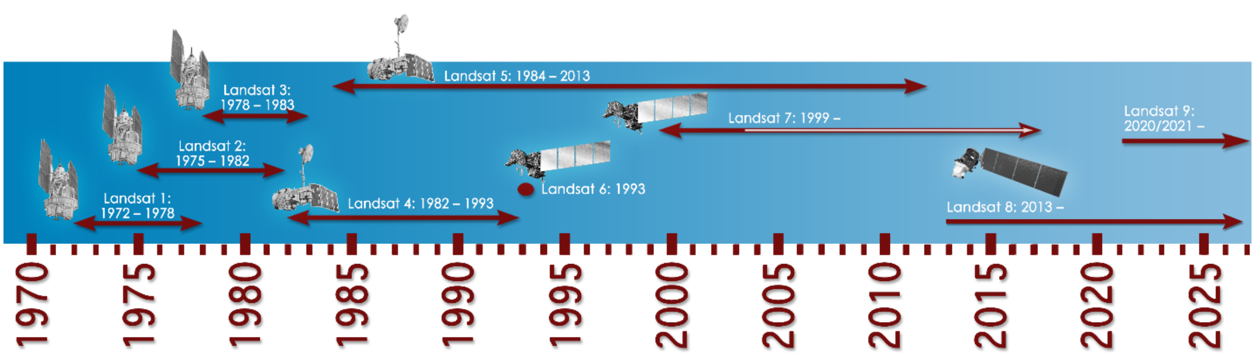
Earth Resources Technology Satellite aka Landsat

It was images like those first grainy black and white pictures and later those taken by America's first astronauts in the 1960's that inspired the development of the Earth Resources Technology Satellite (ERTS). From the unique vantage point of space, we could now observe Earth using a variety of different instruments to monitor changes over time. The ERTS-1 satellite, wisely renamed Landsat-1, was launched aboard a Delta rocket on July 23, 1972, into a Sun-synchronous polar orbit at an altitude of about 560 miles. In this unique orbit, Landsat could observe the same point on the Earth every 18 days, always with the same solar illumination, allowing for precise monitoring of changes on the ground over time.



Landsat 1 undergoing prelaunch checkout (left), atop its Delta rocket awaiting launch (middle), and the terminal used to receive and process Landsat images in 1972 (right). Images courtesy of NASA.

Landsat-1, derived from the highly successful Nimbus weather satellites, carried two instruments that allowed it to take images not only in visible light but also in infrared, well-suited to track changes in vegetation over time. Designed to last only one year, Landsat-1 actually operated for nearly three years, by which time it had been joined in space by Landsat-2, a near identical copy of the original. Since then, ever more sophisticated instruments were flown aboard Landsat-3 through -8, with Landsat-9 planned for launch in 2020, acquiring millions of images of Earth over more than four decades. At first, images from Landsat were processed by NASA and hardcopies sold to users for a fee, a somewhat tedious process. Since 2008, images have been made available to all interested users by the US Geological Survey (USGS) at no cost via the Internet in near realtime.

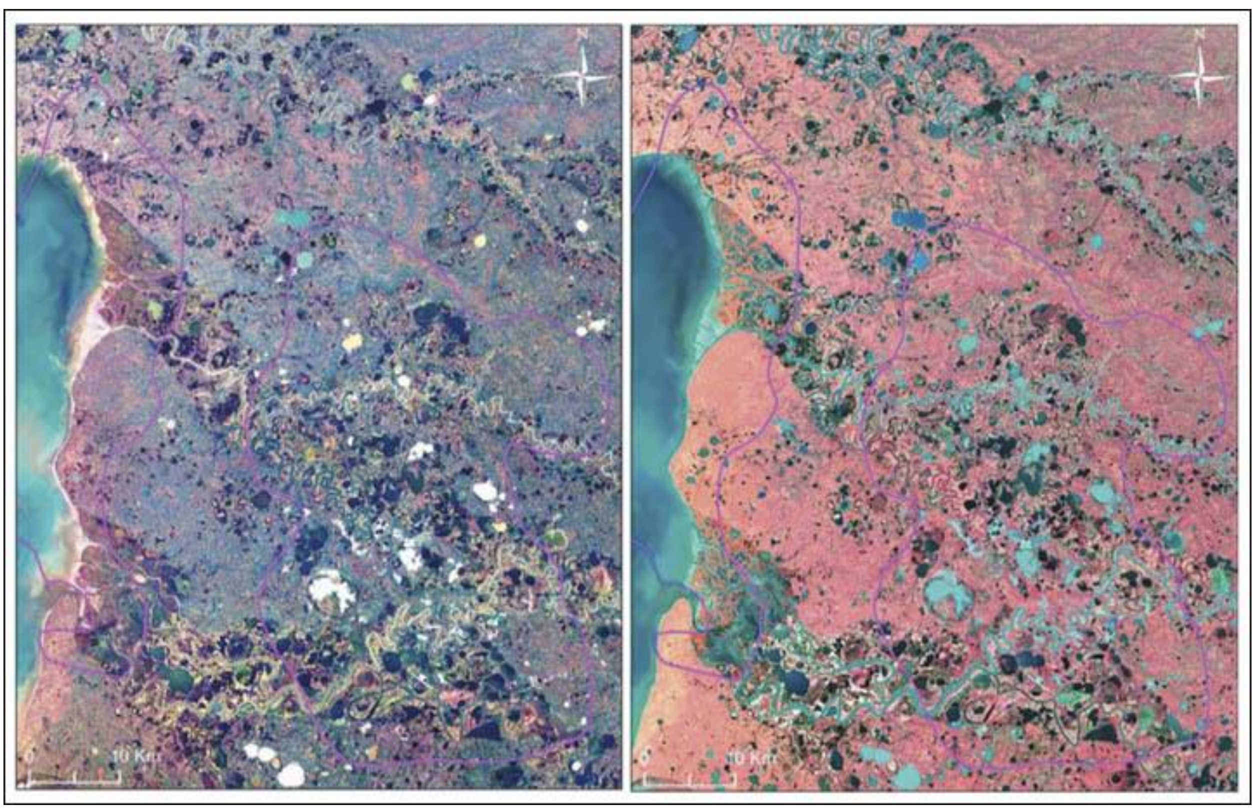


Historical timeline of Landsat satellite operations 1972 to the present. Landsat-5 operated for more than 29 years, the longest lived Earth observation satellite in history. Image courtesy of NASA.

How Landsat helps

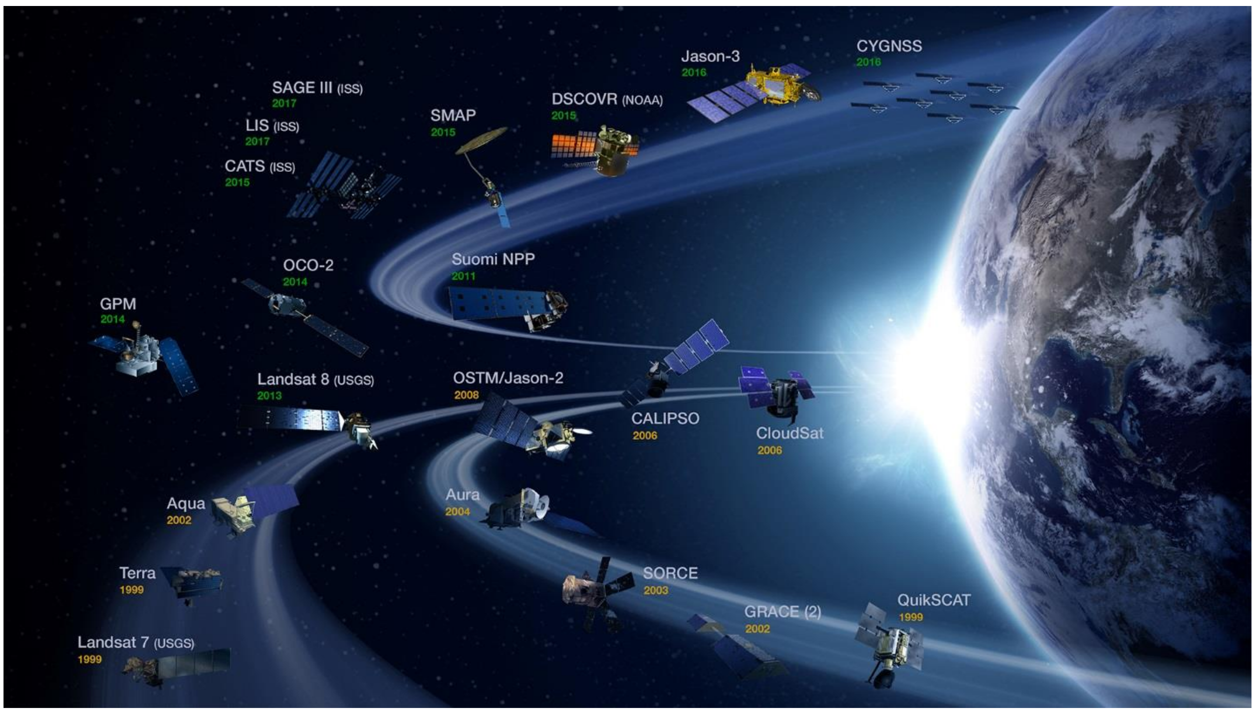
So, how can Landsat help? In short, Landsat looks. And looks. And proves Yogi right. Space-based images from Landsat and other similar satellites offer a unique and critical capability to observe land use over time by providing repetitive observations of the Earth otherwise unavailable. The data provided by the images can be used by scientists and politicians to inform wise decisions in areas such as agriculture, climate, ecosystems and biodiversity, energy, forest management, human health, fire, natural disasters, urban growth and water management. This overview article doesn't allow for examples from each of these disciplines, but details can be found at the following website: https://landsat.gsfc.nasa.gov/how_landsat_helps/. One third of the US economy is influenced by climate, weather and natural hazards, providing strong economic incentives to sustain a healthy space-based Earth observation program.

One example, however, may be illustrative of how Landsat and other space-based observations can be helpful in monitoring and documenting some effects of global climate change. It had been noted since the 1970's that permafrost in subarctic areas like Siberia was melting at an accelerating rate. It also became apparent that this led to the formation of hundreds of melt lakes and the liberation of large quantities of methane, a gas that in the short-term has more potent greenhouse effects than carbon dioxide. The methane turned the water in these lakes blue, making them easy to track over time by satellite. Additionally, the newly released methane has been carbon dated to tens of thousands of years ago, meaning that it had remained frozen since the last Ice Age and therefore hadn't been accounted for in models of the Earth's overall carbon balance. Release of sufficient methane by an increasingly warming climate could actually cause a positive feedback loop in global warming, melting more permafrost and releasing yet more methane. Further monitoring by Landsat and other platforms will reveal whether this process is reversible or whether we've passed the tipping point.



Landsat-8 images of permafrost melt lakes in Siberia emitting methane (blue), in visible (left) and infrared light (right). Images courtesy of NASA/USGS.

In addition to the highly successful Landsat series of satellites, NASA and other agencies such as the National Oceanic and Atmospheric Administration (NOAA) operate a fleet of other Earth observing platforms, many with more specific research goals such as monitoring sea ice levels or atmospheric carbon content. Several instruments aboard the International Space Station also contribute to this overall effort to better understand short- and long-term changes to the Earth. Many of these missions are guided by the 2009 Decadal Survey published by the National Research Council of the National Academy of Sciences. Europe, Russia and China all see the value of space-based Earth observation by deploying their own fleet of satellites.



Pictorial representation of all the Earth observing assets operated by NASA and other Agencies. Image courtesy of NASA.

Returning to Yogi Berra's quote, we are doing a lot of looking at our own planet with a wide array of instruments and are able to observe long term changes, to enable wise and well-informed choices by decision-makers.

For extra credit

For additional information on NASA's and NOAA's Earth observation programs, please visit the following websites:

https://eospso.nasa.gov/; https://science.nasa.gov/earth-science;
https://www.nesdis.noaa.gov/content/our-satellites