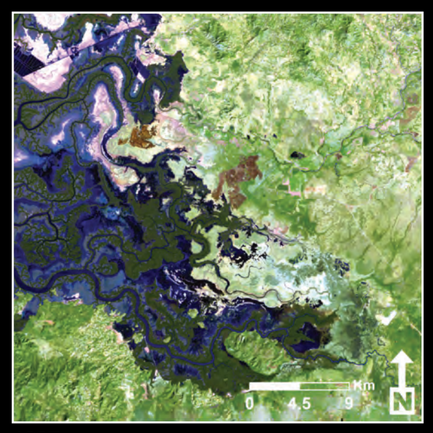
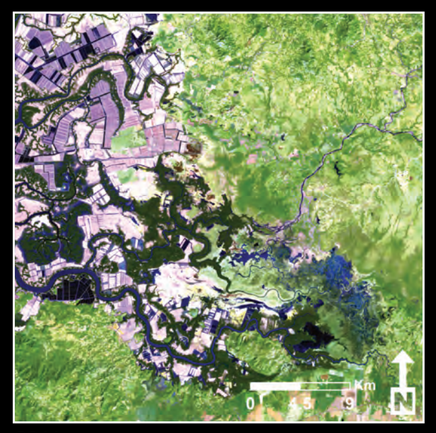
CHANGE *over* TIME

Landsat: Observing Land Cover Change since 1972

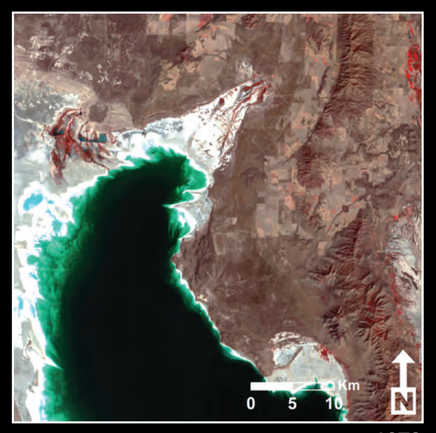
Gulf of Fonseca, Honduras
Honduras is one of Latin America's top producers of cultured shrimp. Huge areas around the Gulf of Fonseca delta have been converted to shrimp farms. When active and filled, the ponds appear dark. When drained, the ponds are pink.



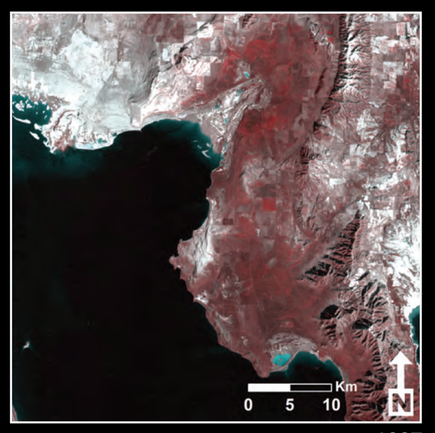
1987



2011



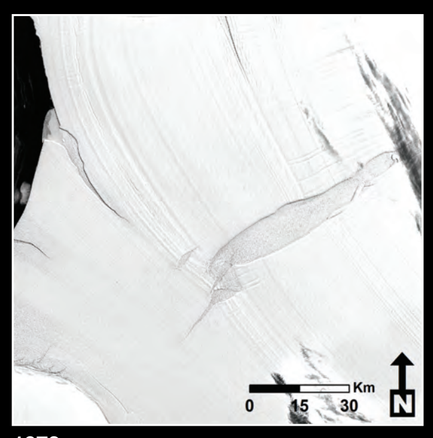
1972



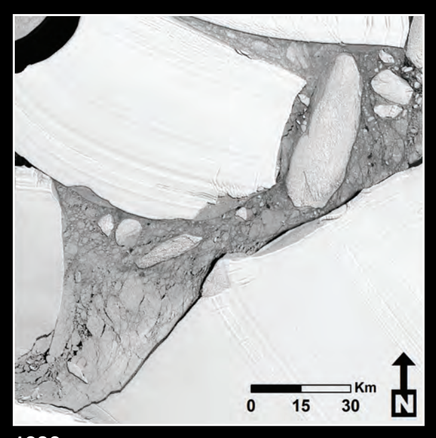
1987

Great Salt Lake, Utah
Great Salt Lake is shallow for its size—about 70 miles long and 30 miles wide, but only about 40 feet deep. Even a small rise in water level means large changes in the surface area of the lake. Rainy weather in the 1980s brought the lake to high levels.

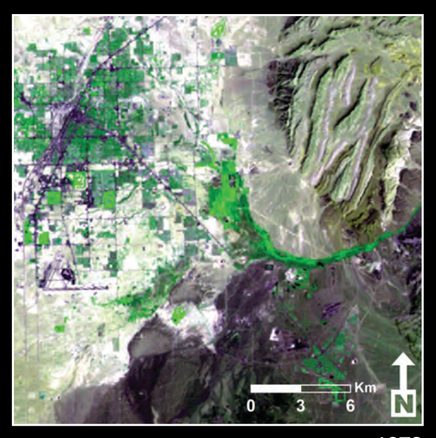
Filchner Ice Shelf, Antarctica
Ice shelves form where glaciers flow into the ocean. In 1986, an area the size of Connecticut broke off the Filchner Ice Shelf, forming several large icebergs that traveled as far as South America. These images show near-infrared reflectance, which discriminates well between ice and water.



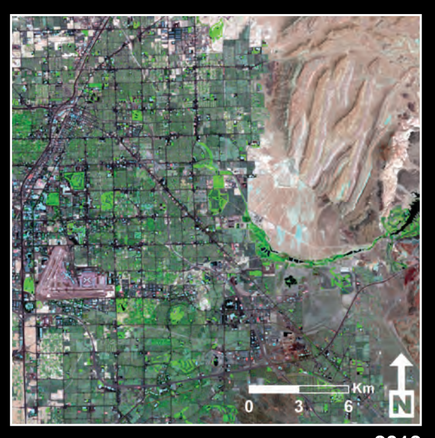
1973



1986



1972

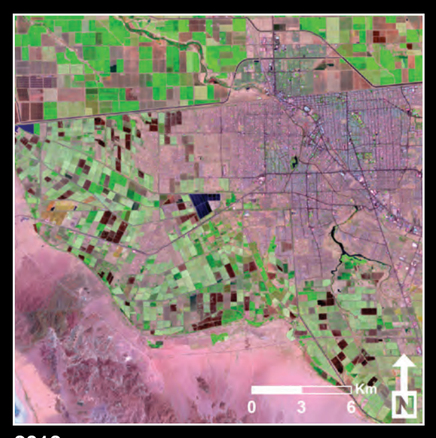


2013

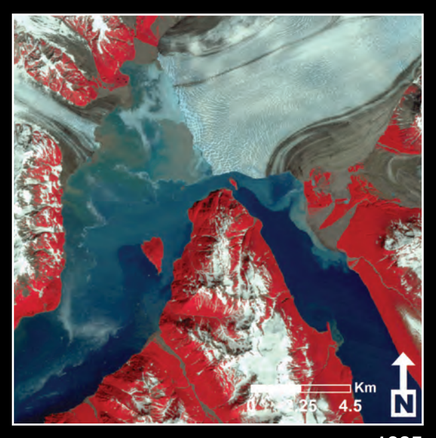
Las Vegas, Nevada
Between 1972 and 2013, the population of Las Vegas grew from 273,000 to over 2 million. Spurred by expansion of the gaming and tourism industries, Las Vegas is one of the fastest growing metropolitan areas in the United States.

Imperial Valley, California
The Imperial Valley lies on the border of California and Mexico. The international border is visible because of the different intensity of vegetation, shown in bright green. The right part of the images shows the growing cities of Calexico and Mexicali.

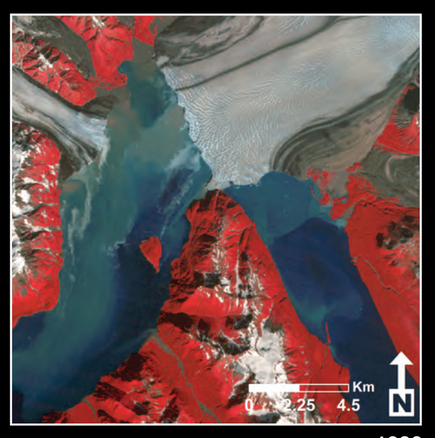
1992



2013



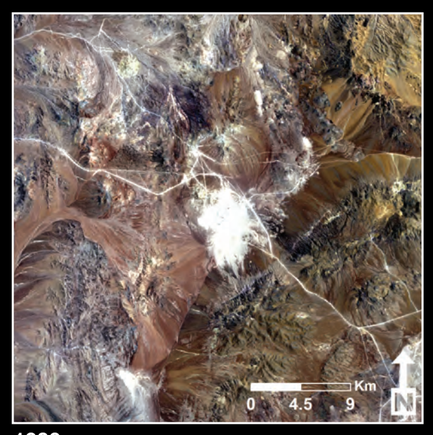
1985



1986

Hubbard Glacier, Alaska
An unusual event on the coast of Alaska was observed with satellite imagery in 1986. A glacier slid down a valley and blocked a fiord from the rest of the bay. The fiord then turned into a temporary lake. The water's level rose 25 meters before the glacier dam gave way a few months later.

Escondida Mine, Chile
Isolated in Chile's Atacama Desert, the open-pit Escondida Mine is the world's largest source of copper. To conserve water and minimize environmental impacts, Escondida created a tailings impoundment that has expanded along with its mining operations.



1989

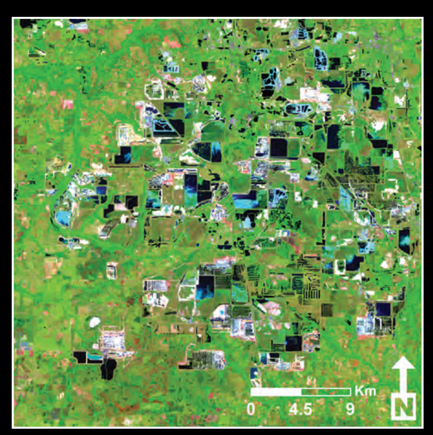
2013

1993

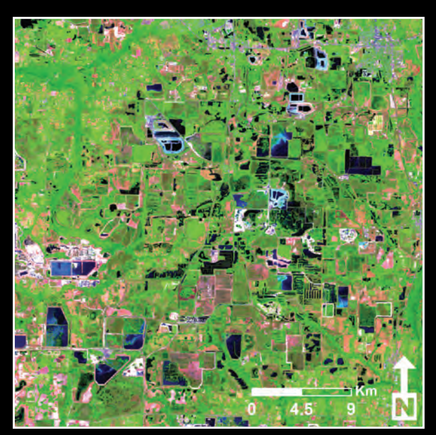
2010

Isahaya Bay, Japan
The controversial Isahaya Bay Reclamation Project has been blamed for recent reduced harvests of fish and seaweed (nori). The 1993 image shows the bay before a sea wall was built.

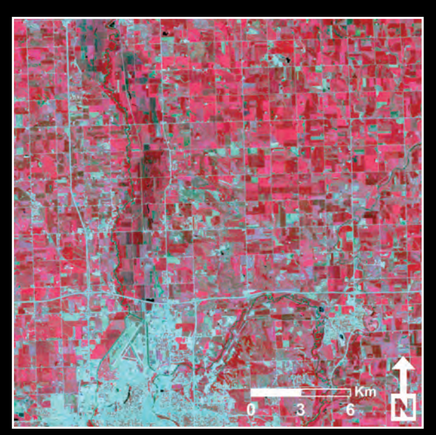
Phosphate Mines, Florida
The world's most productive source of phosphate, a critical nutrient for modern agriculture, lies south of Orlando, Florida. These images show the expansion of the mined area. As the mines shift southward, the land is reclaimed and returns to green.



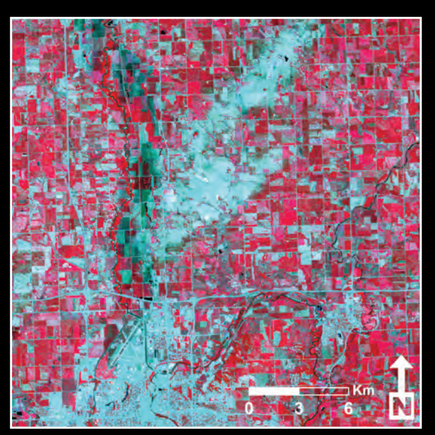
1986



2013



1995



1997

Hailstorm, Sioux Falls, SD
On Sunday, July 13, 1997, an unusually severe hailstorm just missed Sioux Falls, SD. But it pounded the surrounding cropland with baseball to softball-sized hail. Healthy crops appear bright red. Some of these fields appear blue/gray where the hailstorm converted the cropland into bare soil.

NP-2016-6-444-GSFC

Observing Earth with

Landsat Satellites

since 1972

Landsat 8 launched on February 11, 2013

Change is everywhere. We see change best when we can compare things—like before and after images. Landsat helps us do this. Landsat satellites have been imaging our planet over four decades, allowing us to see how the Earth's land surface has changed. Every day, Landsat images provide important information to people who have to make hard decisions about our resources and our environment.

The Landsat series of satellites is a prime example of American achievement in space. Since the first satellite was launched in 1972, Landsat has become an indispensable part of our national infrastructure, providing a decades-long, unique and invaluable record of our changing landscapes—with lots of practical uses for our lives and livelihoods.

Free Data

A series of seven Landsat satellites have collected reliable, consistent, and objective observations of the global land surface for over 40 years. The U.S. Geological Survey (USGS) maintains an archive of images from all seven satellites. In 2008 the USGS opened the archive to the public allowing anyone to search, browse and download over 6 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. This information is recorded digitally for each 30 square meter area on the ground, called 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. 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. 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—allowing us to map a better future.

Preserving our shared

Geoheritage

with Landsat

The geoheritage of our landscapes is the history of humanity. Therefore, continual study and monitoring is vital if we are to preserve this legacy for future generations. Our landscapes can be studied through human as well as technical senses. We can experience our landscapes in person or remotely through images taken from Earth observation satellites.

A Vision for Earth Observation

Fifty years ago, on September 21, 1966, 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." As a result, since 1972, the Landsat series of satellites have been keeping a watchful eye over our planet. Landsat's continuous 44-year accumulation of Earth imagery has documented our changing landscapes and provided stunning images of the Earth.

Building a Legacy

NASA builds and launches the Landsat satellites and then the U.S. Geological Survey operates the missions and preserves the data—currently an archive of more than 6 million images. This archive provides the continuity to observe the evolving geoheritage of our landscapes. In late 2008, USGS opened the entire Landsat collection, with free and open access to decades of continuous data. Use of the imagery and data increased exponentially, from approximately 21,000 scenes distributed annually to over 13 million in 2015.

Benefits to Society

Landsat data, used in combination with today's advanced geographic information systems, image processing software, and cloud computing, enable individual users to process as many scenes as needed for land analysis. For example, many historical images of a single site can now be obtained and analyzed for land-surface change over time, or a user can easily see land-cover or land-use conditions across an entire State or region. Landsat imagery is used in 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 monitor and preserve the geoheritage of our lands.

Monitoring our Geoheritage

Landsat was the first satellite to keep an eye on our Earth, helping people throughout the world monitor and protect our valuable geoheritage for, as the American Geosciences Institute describes, "scientific, economic, ecological, educational, cultural, aesthetic, artistic, and recreational purposes."

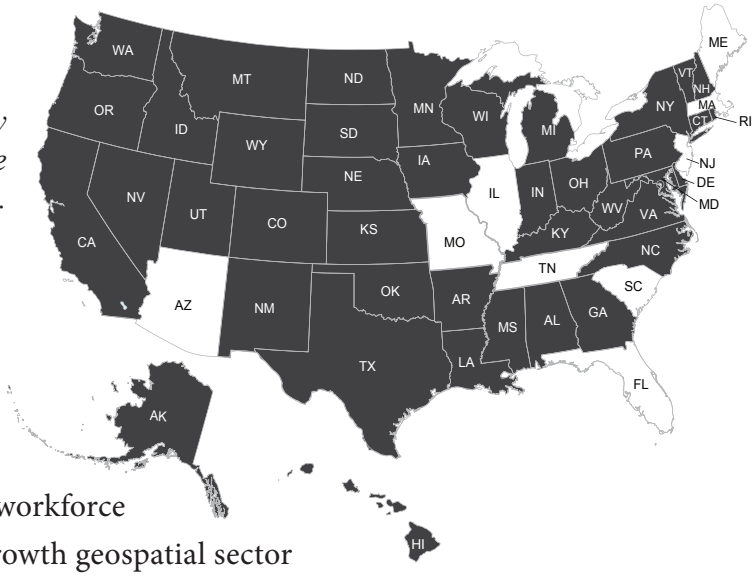
AMERICA VIEW℠ *A Nationwide Consortium*

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.

AmericaView is the outgrowth of a successful 1998 regional pilot project that helped overcome access challenges of using Landsat satellite data. In 2000, Congress instructed the U.S. Geological Survey to implement the vision nationwide, and thus AmericaView, a consortium of member "StateViews," was born.

There are currently 41 StateViews in the AmericaView consortium.



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 STEM education in K-12+ classrooms
- Assists teachers in meeting national and state educational standards for STEM 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 on natural resources

- Improves understanding of water availability and quality issues
- Identifies agricultural challenges and opportunities

Remote Sensing

Discovering Land Cover Changes Over Time

This lesson uses an interactive matching game to compare satellite images of land cover changes over time. Students will explore satellite images from various locations throughout the world and their physical characteristics, identify specific features of land cover change, recognize patterns, and introduction to concepts of digital geospatial data such as resolution and image interpretation.

Level: Grades 6–8

Connections to the Next Generation Science Standards: Disciplinary Core Ideas:
ESS2.A: Earth's Materials and Systems and ESS3.C: Human Impacts on Earth Systems

Materials and Set-up: One change pair set for each group: either copied from this poster or from a pdf available at http://earthshots.usgs.gov/

Access to matching game – either online or offline:

- Online Game accessible at http://www.americaview.org/remote-sensing-memory-game The online version has varying levels of difficulty for elementary to high school students by choosing an age appropriate link and following instructions to play game.
- Offline Game can be played with cards created by cutting out the images on the front of this poster. Glue or laminate colored paper to the backs of the cards so they all look the same when turned over. Be sure to photocopy the content on the back of this poster.
-

Engage: Invite students to play the Memory Game online or use cards assembled from the front of this poster. Players take turns selecting two cards in an attempt to find a matching pair of images from the same location. It may not be obvious since the images weren't acquired in the same year and the land cover will have changed between the images. If the two cards selected are not the same location, they are reset (or turned face down if playing offline). The goal of the game is to match all the image pairs in the shortest amount of time possible. Note: the online version of the game has more pairs and links to information about each location and its change.

Explore: Distribute copies of change pairs to students. Ask students to identify features on each of the images (e.g., deserts, cities, rivers, lakes, farms, etc.). How do they know what each of these features are? What clues lead them to these conclusions? Discuss answers as a group.
Invite students to choose two images of the same place from different times, known as a change pair. Ask students to compare the images and identify what features have changed? How do they know it has changed? Have students record their observations.

Explain: Ask student groups to report out their answers providing evidence to explain the changes they observed.

Background: Landscapes change over time, sometimes very rapidly and other times quite slowly. Change in land cover can have significant effects on humans, animals, and plants. Scientists use remote sensing data to study these changes and how they impact our planet (affecting the air, water, climate, global food supplies, and human health). The Landsat satellites remotely sense visible light as

well as infrared wavelengths of light beyond what human eyes can see. Healthy vegetation reflects near infrared light even more strongly than green light! So, when near infrared light is displayed as red in an image—for example, Hailstorm and Hubbard Glacier on this poster— vegetation appears various shades of red. For more information about how satellite instruments sense light beyond the visible spectrum, see NASA's Tour of the Electromagnetic Spectrum under resource links.

Class discussion questions: Think about how land cover has changed over time in your neighborhood. Have new houses or buildings been built? Are there any new parks? Has a forest been cleared for a farm or for development? Has your local area experienced a natural disaster such as flooding, tornado, or drought? Ask students to write a description of any observed changes over the past 5, 10 or 15 years and illustrate what they think those changes may look like from a satellite?

Evaluate: Students should discuss the following questions as a whole class, in small groups, or in individual journal entries for each of the pairs. Alternatively, students could be assigned one change pair from the front of the poster about which to answer the following questions:

What are the dominant land covers displayed in the images that have changed over the years? What evidence do you see that may have caused these changes? How can satellite images be used to predict potential changes? How do these changes impact human life? What are some strategies that may mitigate the environmental and human health impacts of the change?

Extend: Invite students to search for a pair or series of 'change over time' images. Create a poster including background description, evidence of change, and present to the class. See "World of Change" and other websites listed below.

Additional Resources for Educators

Landsat resources at NASA: http://landsat.gsfc.nasa.gov/?page_id=11

Landsat resources at USGS: http://landsat.usgs.gov//links_educationallinks.php

AmericaView education resources: http://www.americaview.org/resources

Geospatial science lessons: http://www.americaview.org/earth-observation-day

AmericaView on Facebook: https://www.facebook.com/AmericaView/

Earth Observatory current news and features: http://earthobservatory.nasa.gov

NASA's Tour of the Electromagnetic Spectrum: http://science.nasa.gov/ems

Landsat data access: http://landsat.usgs.gov

World of Change: http://earthobservatory.nasa.gov/Features/category.php?cat_id=1567

Earth as Art gallery of Landsat images: http://eros.usgs.gov/imagegallery/

Landsat image gallery: http://landsat.visibleearth.nasa.gov

Landsat visualization gallery: http://svs.gsfc.nasa.gov/Gallery/Landsat.html

Remote Sensing - You got it!

If you have ever searched for an address or looked for an overhead view of your home, you are benefiting from applications that use remote sensing. But have you ever thought about the technology behind how these images are collected? Join Earth Observation Day (EOD) day and follow an exciting tour into the world of remote sensing.

What is Earth Observation Day?

EOD is a Science, Technology, Engineering, and Mathematics (STEM) 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!

How to Get Involved and Support for Teachers

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. You can also find information on how to contact your local StateView coordinator for support and guidance on geospatial resources, and classroom visits by scientists.

Students experiment with ALTA TM spectrometers to measure spectral reflectance of different vegetation types

We would love to hear about your experience putting our educational materials into action. Follow Earth Observation Day on Twitter: **@EarthObsDayAV** and like us on Facebook: **https://www.facebook.com/EarthObsDay/**