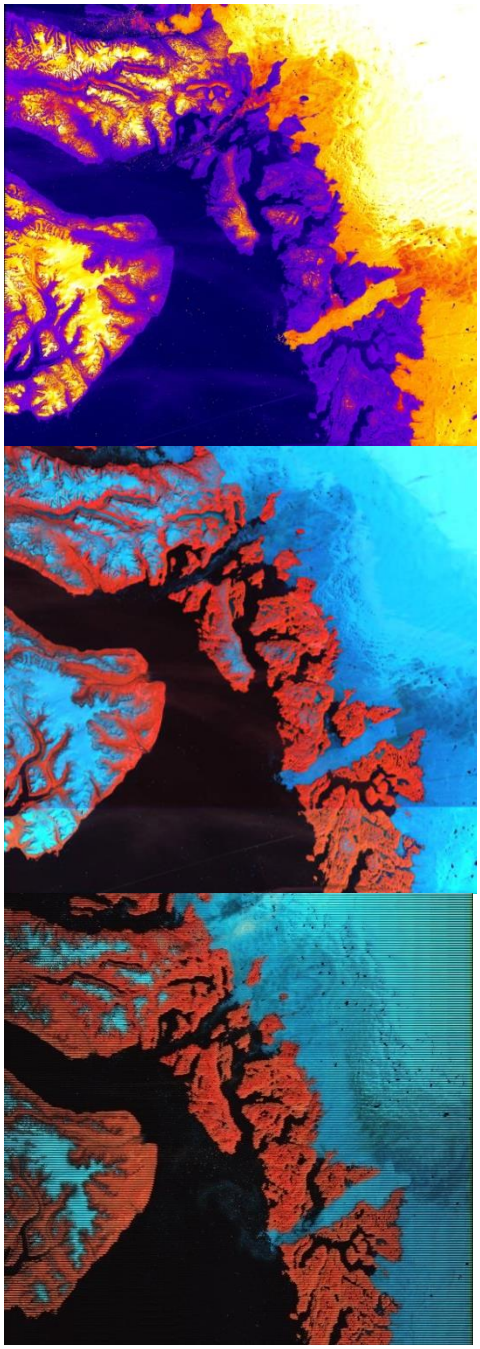


GloVis

USGS Global Visualization Viewer

More Lessons from the Sky
Satellite Educators Association
https://SatEd.org

Please see the Acknowledgements section for historical contributions to the development of this lesson plan. This form of "GloVis USGS Global Visualization Viewer" was published in November 2014 in "More Lessons from the Sky," a regular feature of the SEA Newsletter, and archived in the SEA Lesson Plan Library. Both the Newsletter and the Library are freely available on-line from the Satellite Educators Association (SEA) at this address: https://SatEd.org.

Content, Internet links, and support material available from the online Resources page revised and updated June 2023.

SEA Lesson Plan Library Improvement Program

Did you use this lesson plan with students? If so, please share your experience to help us improve the lesson plan for future use. Just click the Feedback link at https://sated.org/library/search.htm and complete the short form on-line. Thank you.

GLOVIS

Global Visualization and Analysis

Invitation

Since artificial satellites first orbited Earth in 1956, scientists, both amateur and professional, have collected and studied the vast amounts of observations made by, and transmitted to us, from sensors on those satellites. Most of these data are archived in databases that have been used only by expert investigators trained in the use of specialized retrieval techniques and analysis tools.

More recently, the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Geological Survey (USGS), among others, have developed online tools for easy retrieval of archived data in various forms that serve the needs of every level of scientific research including middle and high school grade levels.

This hands-on tutorial guide is an introduction to **GloVis**, the USGS Global Visualization Viewer (GloVis), a quick and easy online search tool for selected satellite and aerial data. GloVis provides access to imagery from aerial surveys, EO-1, and Landsat satellites among others. Following the tutorial steps, learners will experience the value and utility of GloVis for themselves while becoming familiar with its "look and feel" as they investigate changes in Greenland's Jacobshavn Glacier.

Grade Level:	6-12
Time Requirement:	2 class periods
Prerequisites:	None
Relevant Disciplines:	All

Student Learning Outcomes

By the end of this lesson, students should be able to do the following:

- Use GloVis, an online data retrieval and visualization tool from USGS
- Access satellite-based remote sensing data from USGS archives
- Demonstrate knowledge of how to use GloVis independently
- Analyze and interpret sequences of images
- Construct explanations for the interpretations
- Assess the value of various graphical displays of data generated with GloVis
- Communicate findings with others

Lesson Description

GloVis is a web application that provides an easy way to “view, order, and download remotely sensed data.”
(https://www.usgs.gov/centers/eros/science/glovis-short-and-simple-tutorial)

This tutorial lesson is intended to supplement existing curriculum in order to add GloVis to the student's toolbox of data acquisition skills. By way of introduction to GloVis,

learners will take a built-in tour of GloVis, and, following this tutorial guide, they will access, visualize, and analyze selected data. Learners are then invited to explore the available image collections by repeating the process to retrieve data of their own choosing. They will access image metadata from which they will extract source and parameter information related to their selected data and enhance their explanations of the generated imagery and use of GloVis. Throughout the tutorial, learners will encounter questions to be answered on a separate answer sheet.

This is a web-based activity that requires computer terminals with Internet access for each student or group of students. It is recommended that no more than two to four students be assigned to a computer at one time.

While no prerequisite is listed for this activity, the tutorial would be much more meaningful if students had a reason for learning how to use GloVis. For example, learners may want to access and visualize satellite imagery of polar ice to determine how the ice extent is changing. Some knowledge ahead of time of satellite remote sensing and remotely sensed datasets would be valuable.

Important Terms

Calving (glaciers)	Interpolate	Longitude
Glacier	Landsat	Metadata
GloVis	Latitude	Terminus (glacier)

Assessment Suggestions

Summative assessment: correct completion of the answer sheet and determination of whether learners are able to use GloVis to obtain sufficient data relevant to their own investigations. This is best determined when individual learners are able to complete the Your Turn extension activities on their own. Formative assessments can be made while learners work through the tutorial and the teacher circulates to monitor student-computer and student-student interactions.

Next Generation Science Standards

The Next Generation Science Standards present performance expectations for assessment of learning. Each suggested assessment task bundles together a disciplinary core idea, science and engineering practice, and crosscutting concept that are to be connected in the same lesson. The National Research Council (NRC) states that standards must take into account that students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry. At the same time, they cannot show competence in practices except in the context of specific content. Following that line of reasoning, the NRC identified eight practices of science and engineering that are essential for all students to learn:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking

6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

The tutorial guide in this lesson plan is meant to augment curriculum and instruction of other content by providing broader access to specific data that may otherwise not be available to middle and high school students in the course of learning about that other content. Therefore, this lesson plan does not emphasize any specific core content, but rather supports the learning of appropriate practices associated with many content core ideas. Of the eight identified science and engineering practices listed by the NRC, this lesson plan supports the learning and teaching of these specifically:

3. **Planning and carrying out investigations**
4. **Analyzing and interpreting data**
5. **Using mathematics and computational thinking**
8. **Obtaining, evaluating, and communicating information**

Components of each of these practices can be found in the Next Generation Science Standards at all grade levels K-2, 3-5, 6-8, and 9-12 and associated with disciplinary core ideas and performance expectations for all subject areas.

Preparation

The lesson plan document is supplied in portable document format (PDF). An acceptable PDF viewer such Adobe Reader or equivalent is required to read and print the document. The Student Activity pages are also available in Microsoft Word document (DOCX) format to allow teachers greater flexibility in adapting the lesson pages to meet the varying needs of curriculum, students, and classroom situations.

The tutorial guide in the Student Activity pages should be duplicated and distributed one copy per learner group or one to each student for reference. The answer sheet in the Student Activity section should be duplicated and distributed to each student.

GloVis is a web-based application made available by the United States Geological Survey (USGS). It requires an Internet enabled computer and a competent, up-to-date web browser. Much of the exercise can be accomplished online. It is recommended that learners work in groups of two to four at each computer.

Landsat scene image data files can be very large with prohibitive download times. When learners reach Question 17 in the Student Activity pages, the teacher will provide each student computer with image files for June 25, 2000 and July 15, 2013 that have been pre-processed to reduce file size and download times. These files can be downloaded from this lesson's Resources page at https://SatEd.org/library/Resources.htm. Scroll down and click the name of the lesson to see a list of available image files. If needed, when students reach the Your Turn activities, they can save their own images using the computer's screen capture option. (See Student Activity pages.)

Be aware that the image files provided by USGS for downloaded are very large with download times that may be prohibitive during normal class time. Additionally, downloading or saving image data files directly from USGS in GloVis requires the user

to register a username and password with USGS. It is a quick and easy process online with no cost. At the end of these Teaching Notes can be found a tutorial for obtaining a USGS user account and downloading your own images. It is suggested that only the teacher create an account and then download student-requested images outside of class time and make the downloaded files available to student computers as needed.

Once downloaded, a decompression and extraction program is required to access files in the **.zip** or **.tar.gz** folders. While computer operating systems have some decompression (expansion) capability, 7-Zip and Stuffit Expander have been remarkably reliable for decompression and extraction. Both are free of charge, easy to install, and very easy to use. 7-Zip is available in 32- and 64-bit configurations for Windows from https://www.7-zip.org/. Stuffit Expander for Windows or Macintosh is available from https://www.stuffit.com/.

ImageJ was used to process the image described on page 6. ImageJ is a powerful, high-quality, scientific image processing program originally developed by the National Institute of Health for medical imaging and research. Now in the public domain, it is downloadable from https://imagej.nih.gov/ij/. More information about using ImageJ and MultiSpec to visualize and analyze Landsat imagery can be found in the SEA Lesson Plan Library's Analysis Toolbox at https://SatEd.org/library/Tools.htm and the lesson modules **How Landsat Works** and **Land Cover Change** found in the SEA Lesson Plan Library at

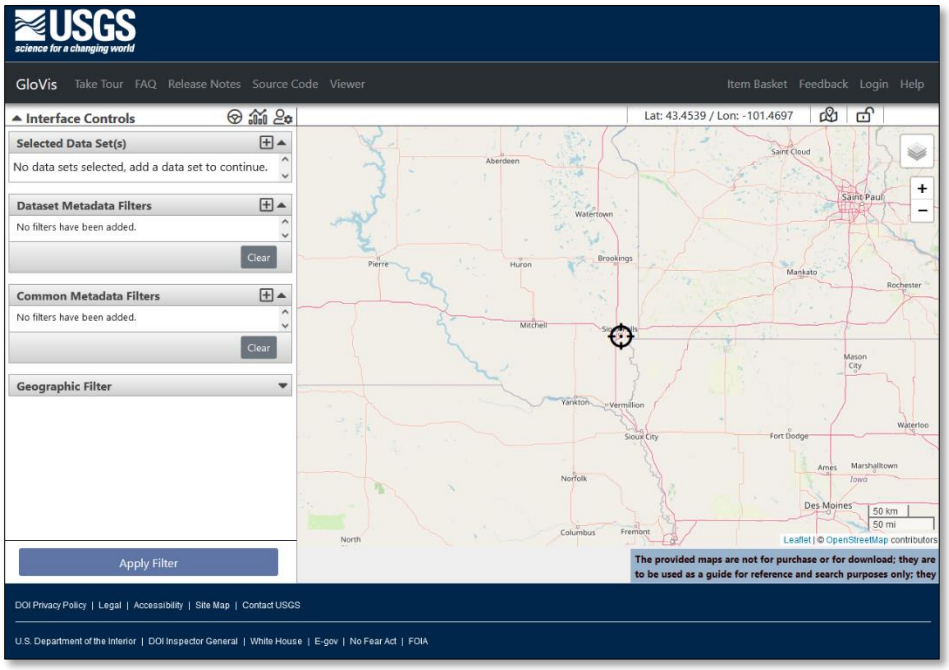
https://SatEd.org/library/LESSONS/Landsat/Landsat.pdf and
https://SatEd.org/library/LESSONS/NDVI/NDVI.pdf, respectively.

Background

Throughout this edition of Teaching Notes and the associated Student Activity, it has been assumed that learners have already been introduced to environmental satellites, some of their remote sensors and products. If needed, an introduction to satellites including environmental satellites, remote sensing, remote sensing datasets, and no-cost, high quality, professional software packages for visualization, analysis, and interpretation can be found in Using Satellites in Education, a part of SatEd.org. It is located at https://SatEd.org/satellites.htm. It is also accessible from the SEA Library's Analysis Toolbox at https://SatEd.org/library/Tools.htm.

GloVis is an acronym of the U.S. Geological Survey that stands for **Glo**bal **Vis**ualization Viewer. It is an easy-to-use graphical user interface related to the USGS Earth Explorer. It allows easier access to the satellite and aerial survey scenes in the USGS Earth Resources Observation Science Center (EROS) inventory. You can access GloVis at https://glovis.usgs.gov/. The login button is in the header. Although not required, it may be helpful to look at that page now while reading through the following material.

When planning to use GloVis as a data search and retrieval tool, consideration should be given to the type of data available in the EROS collections, including their sources, and the data format.



Collections and Data Sources

Selecting a data collection for use depends on the research question or hypothesis under consideration including the time period of interest. For example, if the question relates to land cover in 1990, the investigator might access Global Land Survey imagery. On the other hand, interest in global cryospheric changes might lead an investigator to more recent Landsat imagery. Access the following data collections using **Select Data Set(s)**. Click the ℹ next to each on screen for more information.

- **DOQ** (Digital Orthophoto Quadrangles) – computer generated images of aerial photography in 3.75 minute and 7.5 minute quadrangles.
- **EO-1 ALI** – Advanced Land Imager (10 spectral bands) on Earth-Observing One (2000-2017)
- **EO-1 Hyperion** – Hyperion (220 spectral bands) on Earth-Observing One (2001-present)
- **Global Land Survey** – from Landsat imagery (1972-2012)
- **IRS** – Advanced Wide Field Sensor (AWiFS) and Linear Imager Self-Scanning Sensor (LISS-3) on Resourcesat-1 and Resourcesat-2 (USGS partnership with Indian Space Research Organization) (2003-present)
- **Andsat 8-9 OLI/TIRS** – Operational Land Imager and Thermal Infrared Sensor on Landsat 8 and Landsat 9 (2013-present)
- **Landsat 7 ETM+** – Enhanced Thematic Mapper Plus on Landsat 7 (1999-2003; 2003-present with data gaps)
- **Landsat 4-5 TM** – Thematic Mapper on Landsat 4 and 5 (1982-2012)
- **Landsat 1-5 MSS** – Multispectral Scanner on Landsat 1-5 (1972-1992)
- **OrbView-3** – commercial, high-resolution imagery; panchromatic (black & white) and multispectral (color) (2003-2007)
- **SRTM** – Shuttle Radar Topography Mission (February 11-22, 2000)

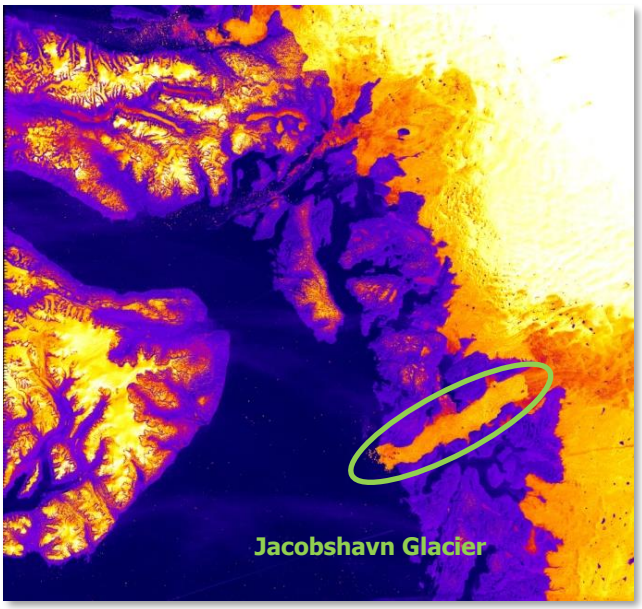
Data Format

Data retrieved with GloVis and displayed on-screen have already been processed to Level 1, 2, or 3. NASA defines these image data processing levels in the chart below.

Level	Description
0	Reconstructed, unprocessed instrument and payload data at full resolution, with any and all communications artifacts removed.
1a	Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with radiometric and geometric calibration coefficients and georeferencing parameters computed and appended but not applied to Level 0 data. Level 0 data are recoverable from 1a data.
1b	Level 1a data that have been processed to sensor units; not all instruments have Level 1b data; Level 0 data are not recoverable from Level 1b data.
2	Derived geophysical variables at the same resolution and location as Level 1 source data.
3	Variables mapped on uniform spacetime grid scales, usually with some completeness and consistency (e. g., missing points interpolated, complete regions composited from multiple orbits, etc.).
4	Model output or results from analyses of lower level data (i. e., variables that were not measured by the instruments but instead are derived from these measurements).

One needs only call up GloVis in a competent browser to view Landsat scene images.

Learners are asked to obtain and use only the natural color image in this lesson. Teachers may explore other image types to determine the best fit for students and curricula.



For example, this JPEG is the from Band 8 (panchromatic) from the Level 1 Landsat Collection Product Bundle download. It was extracted from the G-Zip compression and the TAR collection with 7-Zip. The high-contrast between land, water, snow, and ice in this gray-tone image was further enhanced with ImageJ to produce these striking color differences for easy identification of features. It was also rotated and cropped with ImageJ.

Some background information about glaciers may be helpful here. Alison Giffoni, teaching about the Physics of Glaciers at the University of Alaska, Fairbanks, defines a glacier as "any perennial body of ice that flows under its own weight due to gravity" on this class web site:

http://ffden-2.phys.uaf.edu/webproj/212_spring_2014/Alison_Giffoni/alison_giffoni/Index.html

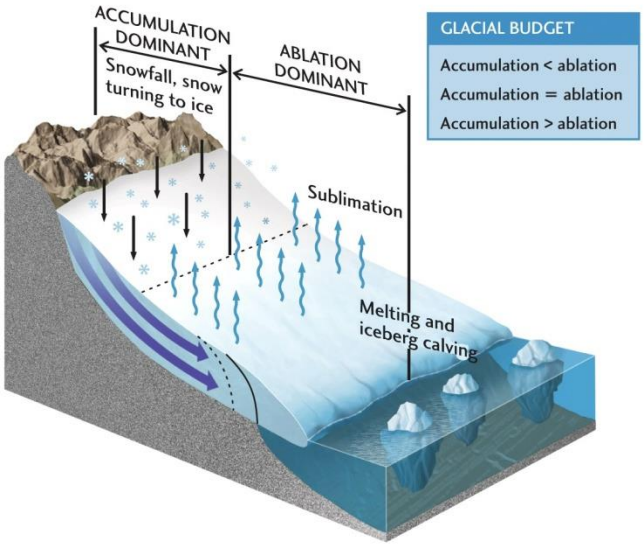


Image: http://ffden-2.phys.uaf.edu/webproj/212_spring_2014/Alison_Giffoni/alison_giffoni/Slide2.html

As illustrated above, a glacier has two general parts, the accumulation zone and the ablation zone. The accumulation area is where the snow turns to ice and adds to the glacier. In the ablation zone, the total rate of sublimation, melting, and calving (chunks of ice breaking off and floating away as icebergs) is greater than the rate of accumulation. The terminus is the edge of the glacier where the ablation zone meets the water. If there is more ice removed from the glacier than is added, the glacier is said to be retreating.

The image of the Jacobshaven Glacier obtained with GloVis and processed with ImageJ can be downloaded for printing or projection from this lesson's online resources page at https://SatEd.org/library/Resources.htm. (NOTE: USGS requires that any USGS scenes that have been modified by further processing be accompanied by mention of the modifications.) Coupled with the data scenes obtained by learners, this image could be used for engagement in a 5E inquiry about glacial movement. Can learners identify the accumulation and ablation zones in the scenes they obtain with GloVis? Can they locate the terminus? Is this glacier advancing, retreating, or neither? What further evidence is needed to reach reasonable answers to these questions?

On the other hand, remember, the point of the lesson is learners developing familiarity with GloVis in order to use it again for other lessons or their own research. As mentioned in the Assessment section, you will know, and learners will know, that they have developed said familiarity when they can use GloVis to obtain desired scene images on their own. Generally, that skill is demonstrated in the Your Turn activities. It should be required that every learner complete at least two (2) of the Your Turn activities for this lesson.

Regarding the graph in the first Your Turn activity, it is recommended that learners use

a computer-based graphing program such as Microsoft Excel or Vernier's Graphical Analysis. Since the glacier seems to be moving from east to west (changing longitude), it is suggested the graph be constructed with the time (year) as independent variable and the longitude as dependent variable.

The second Your Turn activity examines imagery from other sensors and satellites. The Jacobshavn Glacier is more difficult to see clearly in scenes from other satellites. This is due in part to the ground paths, the sensors' viewing angles and fields of view compared to Landsat. In the image on page 6, the Landsat satellite was almost directly over the glacier whereas satellite ground paths are more often farther east or west.

Jacobshavn Isbræ in West Greenland. Photo: Konrad Steffen

To help cultivate an awareness of ground path and row numbers related to satellite orbits, an animated NASA video clip illustrating the scan path of Landsat sensors is found at https://svs.gsfc.nasa.gov/11475. A complete description of the Worldwide Reference System (WRS) of the path and row pattern of Landsat scans is available at https://landsat.gsfc.nasa.gov/about/worldwide-reference-system.

The subject of Greenland glaciers and polar ice (both Arctic and Antarctic) was selected as the exemplar for use of GloVis in this lesson. Many other possible subject areas can provide focus for this tutorial exercise. Landsat was selected because it is the longest continuous global record of the Earth's surface in existence – 1972 to present day. Landsat datasets alone provide a global perspective on:

- Natural changes such as flooding from swollen rivers and river delta changes
- Close-up view of human impacts such as oil fires
- Ecosystems
- Urban growth
- Agricultural land use and crop health
- Water resources
- Human health such mosquito habits
- Energy issues and oil exploration
- Natural disasters such as volcanic eruptions, sever storm aftermath, tornado and tsunami damage
- Climate change such as cryospheric changes including glaciers

Any of these topic areas could make a valid research project supported by imagery from the Landsat archive accessed with GloVis. Applications can be found in every subject area.

Teachers are encouraged to check out these resources related to Landsat:

- USGS Landsat Missions (with many resource links)
  https://www.usgs.gov/landsat-missions
- NASA Goddard Media Studios "A Landsat Flyby" (video, 1:46)
  https://svs.gsfc.nasa.gov/10513
- *More Lessons from the Sky* lesson plan "How Landsat Works"
  https://SatEd.org/library/LESSONS/Landsat/Landsat.pdf

At this point, teachers are invited to experience GloVis by trying the tutorial in the Student Activity pages themselves and, if applicable, discover the Landsat archive with specific topics in mind in addition to glaciers and climate change.

Acknowledgements

All satellite-based images in this lesson came from the USGS Earth Resources Observation and Science Center (EROS) archives and were accessed using GloVis.

The page 6 image, as stated above, is a Band 8 gray-tone image from the Level 1 Product download using GloVis for the Landsat 7 scene, Path 10 Row 11, June 2000. It was further processed by the author with ImageJ by changing the lookup table (color palette), rotating and cropping.

Background information about glaciers was taken from an online posting of Alison Giffoni at the University of Alaska, Fairbanks, teaching about the Physics of Glaciers. The accompanying diagram of glacier parts was produced by Outcrop. The photograph of the Jacobshavn Glacier by Konrad Steffen was also included in that posting.

The table of image processing levels is based the one published by NASA at science.nasa.gov. The map of flight paths for Arctic Campaign 2014 was produced M. Studinger for NASA Operation IceBridge. The map of Landsat paths and rows over Nebraska was produced at University of Nebraska, Lincoln. The "Landsat Flyby" video and the WRS-2 map of Landsat paths and rows comes from Landsat Science at NASA's Goddard Space Flight Center.

This edition of Teaching Notes and the material in the Student Activity pages were developed as part of *More Lessons from the Sky* by J.P. Arvedson for the non-profit Satellite Educators Association, Inc. *More Lessons from the Sky* has its roots in an original collection of more than fifty lessons compiled by Satellite Educators Association and published in *Lessons from the Sky,* © 1995 by Amereon, Ltd. *More Lessons from the Sky* is a regular feature of the free, on-line Satellite Educators Association Newsletter. More information about the Satellite Educators Association, its annual Satellites & Education Conference for teachers, international student environmental research collaborative, and access to the Newsletter can be found at https://SatEd.org.

All *More Lessons from the Sky* lesson plans are archived in the on-line SEA Lesson Plan Library available at https://SatEd.org. The web site features a description of the library

contents, Next Generation Science Standards addressed, several search tools for finding lessons easily, separate resource files for lessons where needed, and the library's Analysis Toolbox.

When duplicating or otherwise using any portion of this lesson or its associated materials, full credit to all contributors to the lesson and its associated materials must be included.

Resources

Note: All of these URLs were current and active as of this writing. If any are unreachable as printed, the use of on-line search engines such as DuckDuckGo, Ask, Google, or Bing is suggested to find current links.

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_____. "Download Earth Pro on desktop." Google Earth, Google. Retrieved June 2023 from https://www.google.com/earth/versions/#earth-pro

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_____. "WRS-2 Path/Row (Landsats 4, 5 And 7) and UTM Zones." U.S. Geological Survey. Retrieved June 2023 from https://landsat.gsfc.nasa.gov/wp-content/uploads/2013/01/wrs2.gif For "UTM Zone" and "WRS-1" and "WRS-2" definitions.

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National research Council. *The Next Generation Science Standards, Next Generation Science Standards For States, By States.* Washington, DC: The National Academies Press, 2013. Retrieved June 2023 from https://nap.nationalacademies.org/catalog/18290/next-generation-science-standards-for-states-by-states

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Answers to Questions in the Student Activity

1. What is the first step in finding data with GloVis?
   The first step is selecting a data set.

2. What is the second step in finding data with GloVis?
   The second step is jumping to a specific location of interest and locking the viewer's center point on that location.

3. To help refine your data search, what metadata filters can be applied?
   Answers will vary. Metadata filters include, among others, cloud cover range expressed in percent of image masked by clouds, acquisition date, and WRS path and row.

4. When multiple scenes are displayed, even overlapping, which one is the currently selected scene?
   The currently selected scene is outlined in red.

5. Where are the controls located for changing from the current scene to an earlier or later scene?
   The Previous and Next buttons are located in the Scene Navigator.

6. How can you find the metadata for the currently selected scene?
   To open the metadata for the currently selected scene, click the metadata button in the Scene Navigator.

7. What sorts of information are found in a scene's metadata?
   Answers will vary. Metadata is information about the data used to create the scene image. The metadata file includes information like date of acquisition, specific location, identification codes, and more.

8. Using the mouse cursor, determine the current latitude and longitude of the Map Center Point crosshair in the default street map.
   Answers may vary slightly. The default location of the Map Center Point crosshair is latitude 43.5369 (or 43.5369° N) and longitude -96.7343 (or 96.7343° W).

9. The Map Center Point crosshair marks what special location on the map?
   Students will need help identifying the USGS Earth Resources Observation and Science Center in Sioux Falls, South Dakota. EROS is actually located in the country about 12 miles northeast of Sioux Falls Regional Airport.

10. What is the difference between Dataset Metadata Filters and Common Metadata Filters?
    Some metadata filters such as Acquisition Date and Cloud Cover are available for all data sets. When applied from Common Metadata Filters, they are applied to all enabled data sets. Dataset Metadata Filters are specific to each data set and only apply to that data set.

11. Describe what changes took place on-screen when you clicked **Take Tour**, then **End Tour**, respectively?
    This is the sequence of steps to reset the image display to the default street map and clear all selected scenes. The Map Center Point crosshair returns to downtown Sioux Falls, South Dakota.

12. Scroll down the metadata list and record the Values for these scene attributes. (Hint: Fill in the metadata for the 2013 scene. You will access the metadata for the 2000 scene later.)

Dataset Attribute	2013 Scene	2000 Scene
Landsat Scene Identifier	LE70100112013196EDC00	LE70100112000177EDC00
Date Acquired	July 15, 2013	June 25, 2000
WRS Path and Row	Path 10, Row 11	Path 10, Row 11
Station Identifier	EDC	EDC
Day/Night Indicator	Day	Day
Scene Cloud Cover	1.00	1.00

Scene Center Latitude (dec)	69.60743 (69.60743˚N)	69.61000 (69.61000˚N)
Scene Center Longitude (dec)	-50.95096˚ (50.95096˚W)	-51.04650˚ (51.04650˚W)

13. Describe what you see in the scene.
The image shows a bay on the west coast of Greenland with a large island in the bay. The coast line is uneven with at least one large glacier extending from inland, through the coastal mountain range and into the sea. The water is displayed in a very dark shade of blue, the land near the coast is reddish brown in color, snow is light blue and ice (glacier) is a slightly darker shade of blue.

14. Compare the scene identifier of this scene with the scene identifier of the last scene (recorded in Question 12). Is this the same scene?
There is no difference in the scenes. They are exactly the same. The scene identifiers are identical. The difference is not in the scene but with the method of accessing the scene.

15. The Landsat scene identifier for this scene is LE70100112013196EDC00. Using the scene's metadata you recorded in Question 12, interpret this coded identifier. What does it mean?
With a little detective work, students should be able to glean most of this from the metadata file. However, the suggested USGS Web page spells it out. Landsat scene identifiers are encoded this way:
LXSPPPRRRYYYYDDDGSIVV where…
L = Landsat
X = Sensor (M = MSS, T = TM, E = ETM+, O = OLI, C = Combined OLI and TIRS)
S = Satellite (such as Landsat-7)
PPP = WRS Path
RRR = WRS Row
YYYY = Year of Acquisition
DDD = Day of Acquisition Year (For example: the 196th day of 2013 is July 15th.)
GSI = Ground Station Identifier
VV = Version
So, LE70100112013196EDC00 is a scene scanned by the Enhanced Thematic Mapper Plus (ETM+) instrument on the Landsat 7 satellite, Path 10 Row 11, on the 196th day of 2013. The signal was received by an unidentified station and provided to the collection by EROS Data Center (EDC) in South Dakota. Version number is 00.

16. Why is the clearest portion of the image in the center? Why does the clear portion extend from top to bottom instead of left to right?
The satellite orbit moves the scanning instrument from north to south or south to north over the scene. The remote sensor scans from side to side. The center line of the image is where the scanner looks directly down at the surface whereas the edges of the image are scanned at an angle. The center of the image is the zone of greatest clarity and accuracy.

17. Compare and contrast the appearance of Jacobshavn Glacier in June 2000 with its appearance in July 2013.
At first, the glacier in both scenes appears to be solid. However, in the 2013 scene, the terminus seems to have receded significantly extending the abalation zone with increased calving.

18. Does your comparison suggest Jacobshavn Glacier has retreated significantly between 2000 and 2013?
Yes. The condition of the glacier in the 2013 scene compared to that in the 2000 scene suggests the glacier may be retreating.

19. Is this evidence sufficient to support a conclusion of melting glaciers and rising sea level? Why or why not? Explain.
That the glacier is melting can only be suggested, not confirmed, by just two scenes. Two scenes just thirteen years apart are not enough evidence to support a conclusion that the glacier is melting. Much more evidence is needed to reach a concrete conclusion. Evidence such as 20 to 30 years of scenes and measurements of the terminus position in each for comparison could be a possible starting point. Also, a change in average sea level cannot be detected from just two images.

USGS User Account (optional)

Please note that a USGS user account is not required for completion of this lesson module. It is an optional advantage for the teacher who can access high-speed Internet.

When using GloVis, the **Download**, **Hide,** and **Share** services are available only to registered users who have logged in. Before logging in, these buttons are greyed-out and inactive. To login, one must register with USGS for a user account.

The JPEG scene images provided at https://SatEd.org/library/Resources.htm were downloaded from USGS using GloVis, then processed to about 200KB each. It should be noted the original downloads are 30 to 1500 times larger at 6MB to nearly 300MB each. The time needed to download the original files during a class lesson period is prohibitive. However, in preparation for the lesson, the teacher is encouraged to register for a user account and login in order to explore and download scene image data that are of interest and/or relevant to the lesson presentation.

Obtaining a user account for USGS EROS (Earth Resources Observations and Science Center) is a very quick process online and has no cost.

- **Point your browser to** https://glovis.usgs.gov**.**
- **Click the** Launch GloVis **button**.
- **Find and click the** Login **link on the right side of the menu bar above the map viewer**.
- **Scroll down to, and click, the** Create New Account **button**.
- **Following the instructions on screen, complete the form and click** Continue.

Once you receive confirmation of your new account, you are free to login for complete access to all image data files available from the Earth Resources Observation and Science center (EROS). These same USGS credentials can be used for all USGS publicly available data.

Downloading Image Data Files Using GloVis (optional)

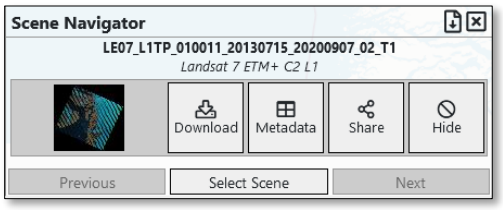
This tutorial will guide you through one pathway for selecting and downloading Landsat scene image data using GloVis.

- **Point your browser to** https://glovis.usgs.gov**, then click the** Launch GloVis **button.**
- **Find and click the** Login **link on the right side of the menu bar above the map viewer.**
- **Type in your** username **and** password**; click** Sign In**.**

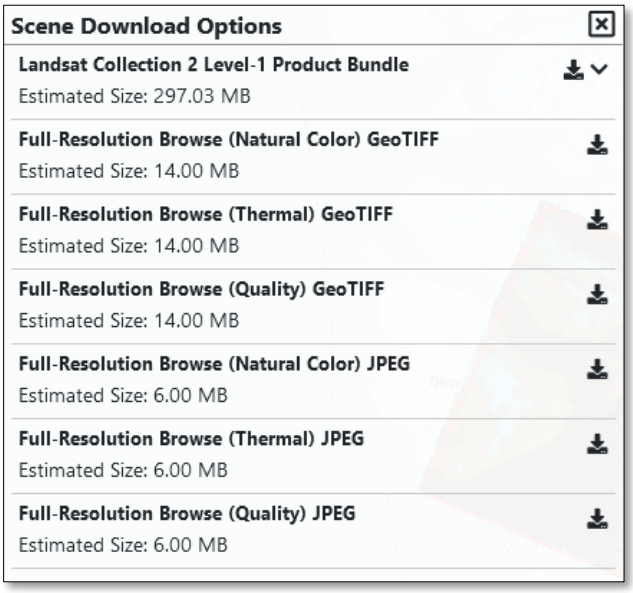
If you have not already reviewed the Student Activity pages for this lesson, do so now for help in performing the following tasks. After logging in, (1) select the desired dataset, (2) jump to the desired location, and (3) lock the center point. (4) Apply the appropriate

metadata filters.

Be sure the Scene Navigator **is visible.**



The use of the **Download** button is <u>not</u> recommended at this time. If you click the Download button, the following list of Scene Download Options is displayed.



- **Landsat Collection 2 Level-1 Product Bundle** is a G-zipped TAR archive containing 28 files (more for Landsat 8) including an image data file for each of 9 wavebands (3 visible and 5 infrared wavebands – two files for Band 6), 3 text files that could be read into specialized visualization programs to produce images, a number of specialized image files, and a quality control image. The bundle can be downloaded *en masse* or the list can be expanded to download each file individually.

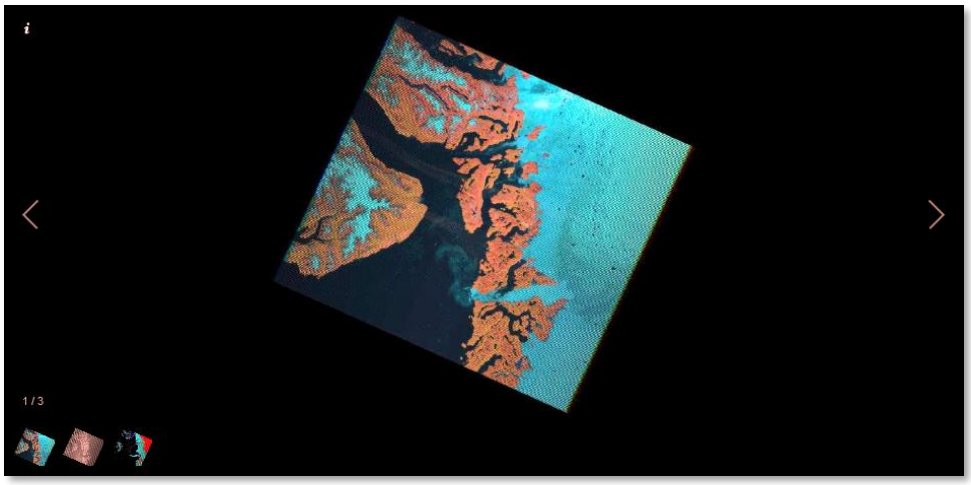
- **Full Resolution GeoTIFF (Natural Color, Thermal, Quality)** are single GeoTIFF images, 8881x8321 pixels and 7 to14MB in size. Each pixel in a GeoTIFF image is georeferenced, that is it carries latitude and longitude information in addition to waveband data. **Natural Color** is a combination of visible red, green and blue, bands to create a "natural color" image. The **Thermal** image appears in gray tones where brighter (whiter) indicates warmer temperatures and darker is cooler. The **Quality** image provides a quick view of the quality of the pixels in the image.

- **Full Resolution JPEG (Natural Color, Thermal, Quality)** are single JPEG

images, 8881x8321 pixels and 4 to 6MB in size. JPEG images are compressed for easier transfer online.

The **Share** button provides easier access to the same list of files for download. For this lesson, the natural color JPEG image will suffice.

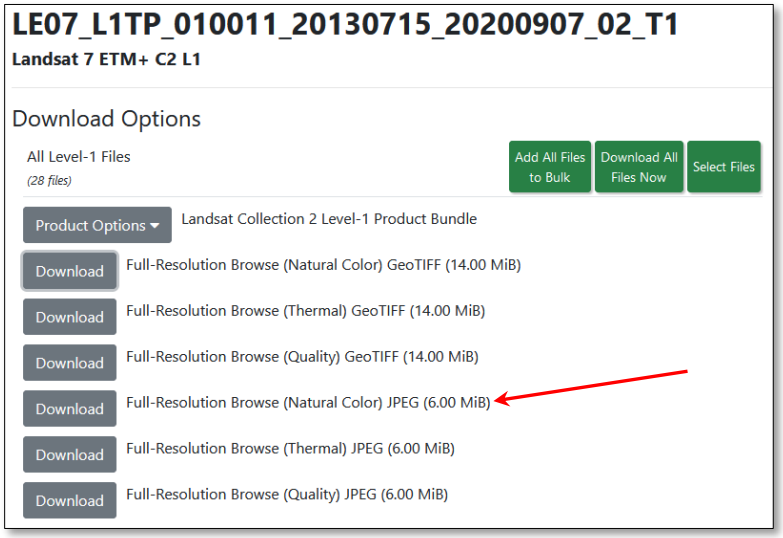
Click the Share **button to display a scene image viewer and image metadata.**



Notice three images can be displayed. Selection of an image here does NOT affect download options.

Scroll down the page below the metadata to find the Download **button. Click the** Download **button.**

A different **Download Options** list is displayed for access to the same files.



Click the grey Download **button to the left of the** Natural Color JPEG **file. (Ignore the green button for now.)**

- **When asked, select** Save file **and click** OK**. Be patient. The download could take some time depending on your download speed connection.**

The requested file will be downloaded to your computer's default download folder.

Feel free to explore other downloads. Individual files from the Product Bundle can be downloaded by clicking the down-arrow in the Product Options button.

Now, clean up **before closing** GloVis:

- **When finished downloading files,** close this browser window or tab**.**
- **Click** Item Basket **in the menu bar. Then click** Clear Item Basket **to insure the item basket is truly empty.** Close this browser window or tab**.**
- **Find and click** Logout **in the menu bar. (IMPORTANT: Do not fail to** logout **before exiting GloVis!)**
- Close **your browser.**

Congratulations. That's all there is to it. You are now able to login and access any image data file the USGS Earth Resources Observation and Science Center has to offer.

GloVis

USGS Global Visualization Viewer

Introduction

Since artificial satellites first orbited Earth in 1956, scientists, both amateur and professional, have collected and studied the vast amounts of observations made by, and transmitted to us, by instruments on those satellites. Most of those data are archived in databases that have been used only by expert investigators trained in the use of specialized retrieval techniques and analysis tools.

More recently, the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Geological Survey USGS), among others, have developed online tools for easy retrieval of archived data in various forms that serve the needs of every level of scientific research including middle and high school grade levels.

This hands-on tutorial guide is an introduction to **GloVis**, the USGS Global Visualization Viewer, a quick and easy online search tool for selected satellite and aerial data. GloVis provides access to imagery from Earth-Observing One and Landsat satellites, among others. Following the tutorial steps, you will experience the value and utility of GloVis for yourself while becoming familiar with its "look and feel" as you investigate changes in Greenland's Jacobshavn Glacier.

What is GloVis?

GloVis is the short name for U.S. Geological Survey's **Glo**bal **Vis**ualization Viewer. According to the USGS, "GloVis is a quick and easy online search and order tool for selected satellite and aerial data. The Viewer allows user-friendly access to browse images from the multiple EROS data holdings." The USGS Earth Resources Observation and Science Center (EROS) *data holdings* are listed in these collections:

- **DOQ** (Digital Orthophoto Quadrangles) – computer generated images of aerial photography in 3.75 minute and 7.5 minute quadrangles.
- **EO-1 ALI** – Advanced Land Imager (10 spectral bands) on Earth-Observing One (2000-2017)
- **EO-1 Hyperion** – Hyperion (220 spectral bands) on Earth-Observing One (2001-present)
- **Global Land Survey** – from Landsat imagery (1972-2012)
- **IRS** – Advanced Wide Field Sensor (AWiFS) and Linear Imager Self-Scanning Sensor (LISS-3) on Resourcesat-1 and Resourcesat-2 (USGS partnership with Indian Space

Research Organization) (2003-present)

- **Landsat 8-9 OLI/TIRS** – Operational Land Imager and Thermal Infrared Sensor on Landsat 8 and Landsat 9 (2013-present)
- **Landsat 7 ETM+** – Enhanced Thematic Mapper Plus on Landsat 7 (1999-2003; 2003-present with data gaps)
- **Landsat 4-5 TM** – Thematic Mapper on Landsat 4 and 5 (1982-2012)
- **Landsat 1-5 MSS** – Multispectral Scanner on Landsat 1-5 (1972-1992)
- **OrbView-3** – commercial, high-resolution imagery; panchromatic (black & white) and multispectral (color) (2003-2007)
- **SRTM** – Shuttle Radar Topography Mission (February 11-22, 2000)

GloVis offers a graphic map display allowing you to view requested scenes of specific areas of interest from selected collection datasets. You can browse to adjacent scenes or select an entirely new one. You will discover many special features such as the ability to view only images with up to a specified amount of cloud cover.

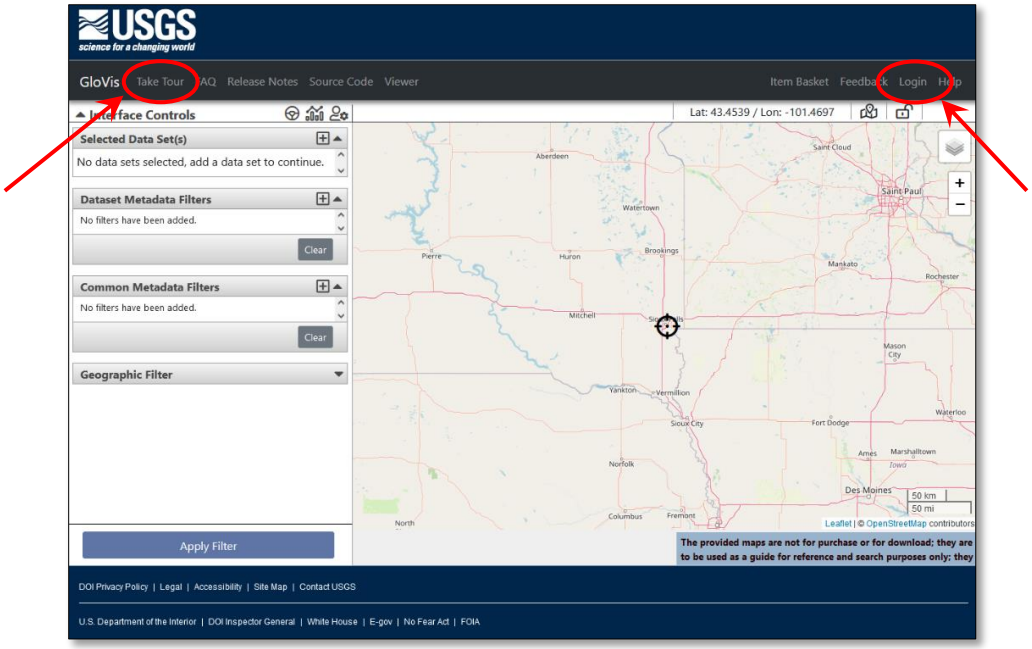
Get started now on a venture to discover how views from above can help us better understand the Earth beneath our feet.

GloVis - Getting Started

GloVis is easy to use!

- **Ensure your computer is Internet enabled. Launch your browser. Point the browser to the GloVis home page at this address:** https://glovis.usgs.gov/**.**

- **On the Welcome to GloVis page, click** Launch GloVis**. This GloVis home page is displayed.**



The built-in quick tour will help you become familiar with fields and switches on the home page screen.

- **Click the** Take Tour **link near the left end of the menu bar above the map display.**

Answer these questions as you take the tour.

1. *What is the first step in finding data with GloVis?*
2. *What is the second step in finding data with GloVis?*
3. *To help refine your data search, what metadata filters can be applied?*
4. *When multiple scenes are displayed, even overlapping, which one is the currently selected scene?*
5. *Where are the controls located for changing from the current scene to an earlier or later scene?*

6. *How can you find the metadata for the currently selected scene?*

7. *What sorts of information are found in a scene's metadata?*

When the tour ends, The Global Land Survey data set is still selected. The Map Center Point crosshair is centered on the map display.

8. *Using the mouse cursor, determine the current latitude and longitude of the Map Center Point crosshair in the default street map.*

- **Click the** Jump to **icon and select** Lat/Lng**. In the coordinate fields, enter latitude** 43.7358 **and longitude** -96.6254**; click** Jump to Location**. Lock the center point.**

What are you looking at in this scene? These tools may help:

- **You can zoom-in and -out using the + and – buttons in the upper right of the image.** Zoom-in **on this location until the building label is visible.**

- **If needed, pan by placing the cursor on the image, holding down the left mouse button, and dragging in any direction.**

9. *The Map Center Point crosshair marks what special location on the map?*

When more help is needed, try these steps:

- **Click** Help **in the menu bar. A new browser tab/window opens.**

- **Notice** Contacts **on the right. It shows how to contact Customer Service at the USGS Earth Resources Observation and Science Center (EROS). Remember where to find this.**

- **Find the bulleted list of help topics and click** GloVis Questions Answered**. Briefly, scan through the questions and answers to become familiar with the type of help available here.**

10. *What is the difference between Dataset Metadata Filters and Common Metadata Filters?*

- **Close the** browser tab **or** window **for the GloVis Help Index.**

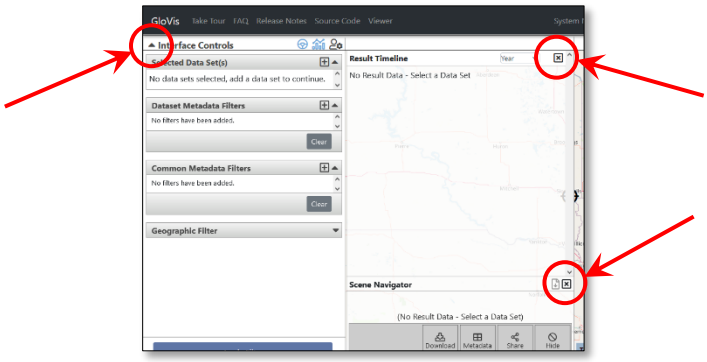
Feel free to refer to the Help section at any time while using GloVis.

Adjusting the View

You can adjust the map view by changing the following settings at any time:

- To see more of the map viewer window…

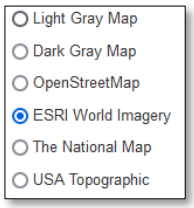
  Close the Interface Controls panel **by clicking the** up arrow**. If open, close the** Result Timeline **and the** Scene Navigator **by clicking the** X **in the upper right corner of each.**



- To change the basemap…

  In the upper right corner of the map viewer, find the layer button. 

  Click the layer button **once to display a list of basemap layers. Selecting** ESRI World Imagery **is recommended. The basemap layers selection popup will close when the cursor is moved out of the popup.**



- To reset the map to the default view…

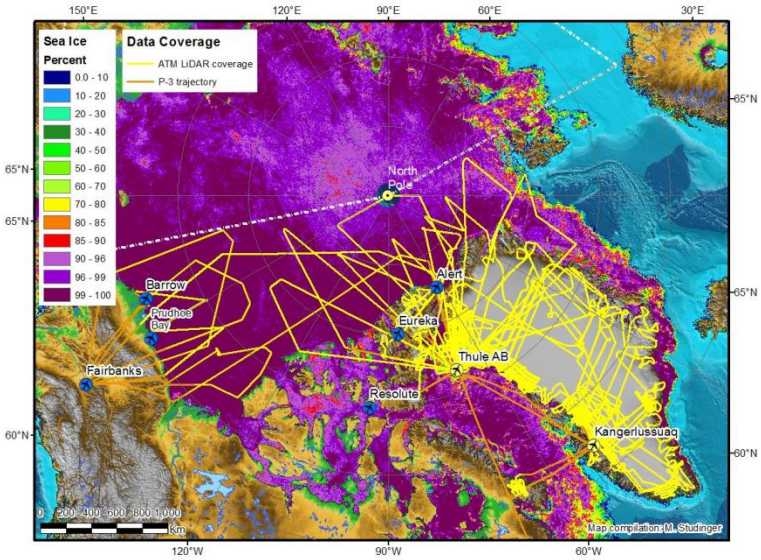
  In this order: click Take Tour**, then** End Tour**. Do not take the tour.**

*11. Describe what changes took place on-screen when you clicked **Take Tour**, then **End Tour**, respectively?*

Accessing Data

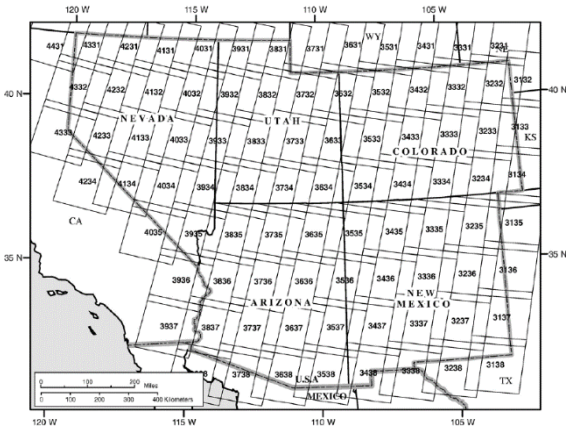
Let's try a simple example. Suppose you are interested in glaciers in Greenland and whether they are advancing or retreating. NASA's ICESat satellite monitored the cryosphere especially in polar ice regions from 2003 to 2009. ICESat 2 was launched in 2018. Operation IceBridge was a six-year mission to survey the Earth's polar ice from the air beginning in 2009. It produced three-dimensional views of Arctic and Antarctic ice sheets, ice shelves, and sea ice. Multiple instruments on these flights provided annual looks at the behavior of ice in Greenland and Antarctica. IceBridge was extended to continue “bridging the gap” in cryospheric data between the functional lives of the two IceSat satellites.

We will focus our attention on a glacier north of Kangerlussuaq, Greenland. The Jacobshavn Glacier was surveyed extensively each year from 2010 to 2014. The fly-over pathways of the 2014 Arctic Campaign are shown in yellow on this map.

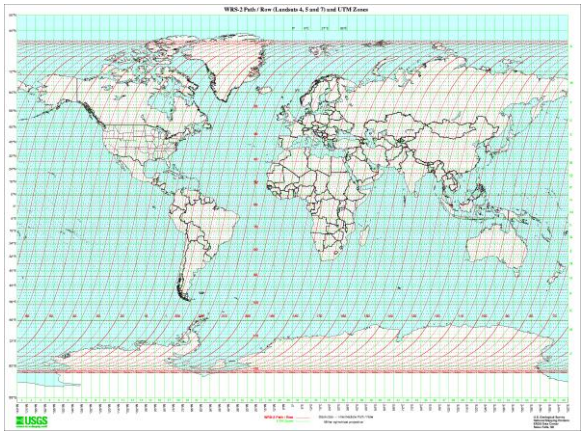


Operation IceBridge: Arctic Campaign 2014
(https://www.nasa.gov/sites/default/files/arctic_2014_map.jpg)

Icebridge data are from instruments on aircraft flying at relatively low altitudes compared to satellites. Satellite-based remote sensing data of polar ice are also available. Landsat Earth-observing satellites have been in orbit since 1972. The orbital path of each satellite is configured so that the entire Earth is scanned every 16 days. As the satellite orbits on a generally north-south path (colored columns in the left image below), its sensors scan the Earth's surface one scene at a time (squares in each column). Each successive scene is called a row in that path. Therefore, in GloVis, scene locations can be identified by **path and row** as well as by the **latitude and longitude** at the center of the scene.



Example of Landsat Paths and Rows
https://www.researchgate.net/figure/Landsat-ETM-scenes-path-and-row-for-the-5-state-region_fig2_249963497



WRS-2 Paths and Rows for Landsat 4, 5, 7
http://landsat.gsfc.nasa.gov/wp-content/uploads/2013/01/wrs2.gif

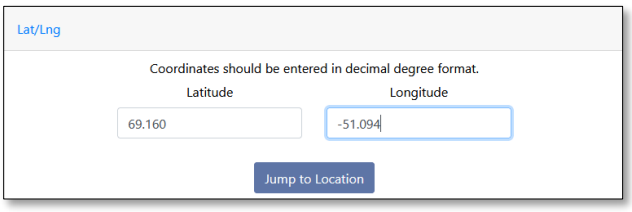
The sensors onboard Landsat satellites scan the Earth in three visible and at least four infrared wavebands. Surface features on the Earth absorb some and reflect other wavebands of solar radiation. By studying the amount of energy in each waveband reflected by various surface features, scientists are able to identify specific surface features in Landsat imagery. The USGS maintains an

archive of Landsat imagery that can be accessed by the general public using the GloVis online tool.

For our example, use an atlas, world globe, or Google Earth to determine the position of Jacobshavn Glacier in Greenland located between the towns of Ilulissat to the north and Claushavn to the south of the glacier.

- **In Selected Data Set(s), click the switch for** Landsat 7 ETM+**, then** Add Selected Data Sets**.**

- **Click the** Jump to **icon and select** Lat/Lng**. In the Latitude field type** 69.160**, and in the longitude field type** -51.094**. Click** Jump to Location**.**



- **It may be helpful here to** lock the center point **by clicking the** lock icon**.**

- **In Common Metadata Filters, set Acquisition Date Range from** 07/15/2013 **to** 07/15/2013**. Click** Add Filter **and** Close**.**

- **Now, examine the scene's metadata. If not already visible, open the** Scene Navigator **if Click the** Metadata **button.**

12. *Scroll down the metadata list and record the Values for these scene attributes. (Hint: Click any field name in the list for more information about that field.)*
    a. *Landsat Scene Identifier*
    b. *Date Acquired*
    c. *WRS Path and Row*
    d. *Station Identifier*
    e. *Day/Night Indicator*
    f. *Scene Cloud Cover*
    g. *Scene Center Latitude (decimal degrees)*
    h. *Scene Center Longitude (decimal degrees)*

- Close **the Metadata window.**

13. *Describe what you see in the scene.*

- **Feel free to** pan **and** zoom **as needed to enhance your observations of the image.**

- **Locate the** Jacobshavn Glacier**. Check with your teacher to be sure you are on target.**

Alternatively, you can also locate Landsat scenes by path and row numbers, if you know them.

- **Reset the map display to the default view. (Did you remember to** Take Tour **to reset?)**
- **Once again, select** Landsat 7**. Then click the** Jump to **button and select** WRS Path/Row**.**
- **Accept the default** WRS Grid Type**. Type in the** path **and** row **numbers you recorded in Question 12. Click** Jump to Location**.**
- **Add a filter for** Acquisition Date **of** 07/15/2013**, as you did before.**

14. *Compare the scene identifier of this scene with the scene identifier of the last scene (recorded in Question 12). Is this the same scene?*

15. *The Landsat scene identifier for this scene is LE70100112013196EDC00. Using the scene's metadata you recorded in Question 12, interpret this coded identifier. What does it mean?*

- **If needed, keep GloVis open while opening the following in a new browser window or tab and use it to complete your answer to Question 15:** https://www.usgs.gov/faqs/what-naming-convention-landsat-collections-level-1-scenes**.**
- **Keeping GloVis open, close the FAQ browser window or tab.**

Viewing the Scene Image

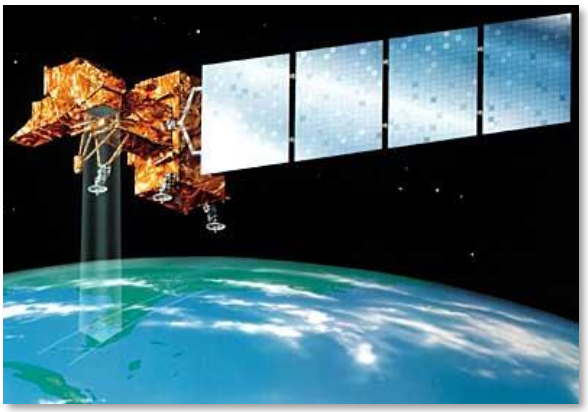
Before examining the scene in more detail, would it be helpful to be able to move the map display in its window?

- **Be sure to** lock the scene center point**. Then** pan **and** zoom **as needed to inspect the image.**

In this image, ice and snow appear light blue, sea water appears very dark blue, and bare land appears reddish to brown. Can you locate the terminus or leading edge of the glacier as it moves into the bay? Can you spot where the glacier is calving – that is, where large chunks of ice are breaking off the glacier and becoming icebergs as they float away in the current?

You may notice there are periodic lines from side to side in the image. These are areas of missing data. The area in the center contains no missing data, but areas closer to the edges of the image frame have more missing data. Missing data have been interpolated to produce an image that appears more complete. The orbiting satellite carries the scanning instrument from north or south over the scene while the instrument scans from side to side. The center of the image is where the scanner looks directly down at the surface whereas the edges of the image

are scanned at an angle. The center of the image is the zone of greatest clarity and accuracy.



Source: Lockheed-Martin

16. Why is the clearest portion of the image in the center? Why does the clear portion extend from top to bottom instead of left to right?

In order to Select Scene, save scene metadata, Download a scene, or Share, you must login with a user account. The needed scene images have already been downloaded for you. Your teacher will provide them when needed.

Melting glaciers and rising sea levels are concerns to be considered when discussing global change. Can melting glaciers or rising sea levels be detected in Greenland using this Landsat image archive? Let's look at an earlier image of the same scene for comparison.

Viewing Multiple Scenes Simultaneously

- **In Common Metadata Filters, change the** start date **to** 06/01/2000**. Click the blue** Apply Filter **button at the bottom of the Interface Controls.**
- **Once the scenes have loaded, click the** icon **at the top of the Interface Controls panel to open the** Result Timeline**.**
- **In the** Result Timeline**, scroll up to the year** 2000**. Click the** 2000 checkbox **to change it to a +. The date in the information bar above the map viewer changes to** 2000-06-16**.**
- **Click the** Next **or** Previous **button in the Scene Navigator until the date in the information bar reads June 25, 2000 (**2000-06-25**).**
- **If necessary, you may** hide **the** Interface Controls panel **to increase the amount of the map viewer visible on the screen by clicking the** up arrow **to the left of** Interface Controls**. Then use** pan **and** zoom **to center your view on the glacier.**

Can you return to the July 15, 2013 scene?

- Scroll down **the Result Timeline to** 2013 **and** click its checkbox**. Then use the** Next **and** Previous **buttons to find the scene with date** 2013-07-15**.**

Screen Capture & Save Image

If your teacher directs you to save a copy of a selected scene, use *screen capture*. To copy the entire screen to the computer's clipboard, press the **Print Screen** button in Windows or **Shift-Command-3** in Macintosh.

- **When the desired scene is displayed in the map viewer, use** screen capture **to copy the image to the computer's clipboard.**
- Paste **the image into your computer's default image viewer or which ever image viewer is recommended by your teacher.**
- Follow your teacher's directions **to save the image to a specific location on your computer.**

Although you may not save images now, you may need this procedure later for the Your Turn activities.

Has Jacobshavn Glacier Expanded or Retreated?

- **If needed, return to the** June 25, 2000 **scene. When it is displayed, open its** metadata file**. Return to Question 12 and complete the chart to compare the metadata of the two scenes.**
- **When finished, you may** exit GloVis **by closing its browser window or tab.**
- **Obtain from your teacher image files for Landsat 7 scenes of Jacobhaven Glacier on June 25, 2000 and July 15, 2013. Open both scene images in your computer's default image viewer. Arrange the windows so you can examine both images side-by-side.**

17. *Compare and contrast the appearance of Jacobshavn Glacier in June 2000 with its appearance in July 2013.*

18. *Does your comparison suggest Jacobshavn Glacier has expanded or retreated significantly between 2000 and 2013?*

19. *Is this evidence sufficient to support a conclusion of melting glaciers and rising sea level? Why or why not? Explain.*

Your Turn

NOTE: Each of these Your Turn extension activities can be accomplished without downloading imagery.

- To demonstrate change in Jacobshavn Glacier over time, more images are needed. Develop and carry out a plan to find and capture one image per year for a span of at least 20 years. Take into account the season of the year, the position of the sun, and the amount of cloud cover as you decide which images to use. Place the cursor over what appears to be the terminus or edge of the glacier where calving begins. Without moving the cursor, record the latitude and longitude of the cursor's location (shown just above the viewer window). You will need to record latitude and longitude with at least 4 decimal places. Similarly record the positions of the glacier terminus in each successive image. Plot a scatter graph with line connecting the points. Plot the year on the x-axis and longitude on the y-axis. How has the glacier behaved over this span of time? How do you know? Share this information with your class. Be prepared to answer questions about your research.

- You have been working with data from the Enhanced Thematic Mapper Plus (ETM+) on Landsat-7. View the Jacobshavn Glacier from Global Land Survey (GLS) collection, the Thematic Mapper on Lansat-5, as well as the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) on Landsat-8. Look for scene images for the month of July in various years. Can you locate the glacier in each image? For purposes of studying this glacier, compare and contrast these images with those from Landsat-7. What are the advantages and disadvantages of each? Consult your teacher to decide the best way to share this information with your class.

- Select a different glacier or surface feature of interest and perform a similar study with a sequence of images from the Landsat, Global Land Survey, or another collection using GloVis. Plan a sequence of imagery to demonstrate how that surface feature has changed over time and the importance of being aware of those changes. Be sure to include in your plan a means of sharing your images and information with your class. Have your plan approved by your teacher and carry it out.

- An image's spatial resolution is the amount of surface area covered by each image pixel. Do all satellite-based images have the same spatial resolution? Take a look at Landsat satellites in particular. Perform an Internet search for information about the spatial resolution of instruments on each Landsat satellite (MSS on Landsat 1-5, TM on Landsat 4-5, ETM+ on Landsat 7, OLI/TIRS on Landsat 8, OLI2/TIRS2 in Landsat 9). Your search might start with USGS Landsat sites and NASA Landsat sites. Explain the spatial resolution of each and how they differ. Using GloVis, find sample imagery from the MSS, TM, ETM+, and OLI instruments to visually compare and demonstrate differences of each. Describe the advantages and disadvantages of higher spatial resolution imagery. For what purpose(s) might higher resolution be important? Consult your teacher to determine the best way to share your discoveries and conclusions.

- Can imagery accessed with GloVis be used to monitor sea level rise in coastal areas? Why or why not? Use GloVis to obtain imagery to demonstrate your answer. Ask your teacher to suggest a method to visually share this information with your class.

- Are you currently investigating something in your class that can be aided by using GloVis? If so, what is it? How will you use GloVis now?

Name_____ Class_____ Date_____

GloVis

Answer Sheet

1. What is the first step in finding data with GloVis?

2. What is the second step in finding data with GloVis?

3. To help refine your data search, what metadata filters can be applied?

4. When multiple scenes are displayed, even overlapping, which one is the currently selected scene?

5. Where are the controls located for changing from the current scene to an earlier or later scene?

6. How can you find the metadata for the currently selected scene?

7. What sorts of information are found in a scene's metadata?

8. Using the mouse cursor, determine the current latitude and longitude of the Map Center Point crosshair in the default street map.

9. The Map Center Point crosshair marks what special location on the map?

10. What is the difference between Dataset Metadata Filters and Common Metadata Filters?

11. Describe what changes took place on-screen when you clicked **Take Tour**, then **End Tour**, respectively?

12. Scroll down the metadata list and record the values for these scene attributes. (Hint: Fill in the metadata for the 2013 scene now. You will access the metadata for the

2000 scene later.)

Dataset Attribute	2013 Scene	2000 Scene
Landsat Scene Identifier		
Date Acquired		
WRS Path and Row		
Station Identifier		
Day/Night Indicator		
Scene Cloud Cover		
Scene Center Latitude		
Scene Center Longitude		

13. Describe what you see in the scene.

14. Compare the scene identifier of this scene with the scene identifier of the last scene (recorded in Question 12). Is this the same scene?

15. The Landsat scene identifier for this scene is LE70100112013196EDC00. Using the scene's metadata you recorded in Question 12, interpret this coded identifier. What does it mean?

16. Why is the clearest portion of the image in the center? Why does the clear portion extend from top to bottom instead of left to right?

17. Compare and contrast the appearance of Jacobshavn Glacier in June 2000 with its appearance in July 2013.

18. Does your comparison suggest Jacobshavn Glacier has retreated significantly between 2000 and 2013?

19. Is this evidence sufficient to support a conclusion of melting glaciers and rising sea level? Why or why not? Explain.