ABSTRACT
Instructors across a spectrum of disciplines and educational levels share a need for convenient access to graphic materials that illustrate the key concepts in their lessons. GloVis is an on-line tool designed by the U.S. Geological Survey to facilitate searches for Landsat and related imagery. The GloVis preview images provide a resource for teachers who need images to illustrate geographic concepts in the context of landscapes local to their institutions. This presentation introduces GloVis’ resources and provides classroom examples illustrating applications at several academic levels. Use of GloVis preview images requires only simple resources, including internet access, a simple image editor, and a resource such as Microsoft PowerPoint. Specific examples include sequential images of the 1988 forest fires in Yellowstone National Park, physiographic provinces, regional phenological changes, New Orleans observed before and after Katrina, strip-mined landscapes in Eastern Kentucky, and suburban sprawl along Virginia’s I-95 corridor, illustrate the capabilities of this resource.

INTRODUCTION
Teachers of geography and related topics across a range of educational levels benefit from convenient access to graphic materials that illustrate key geographic information and concepts. In the geography classroom, access to graphic materials that simultaneously address topical learning objectives and are relevant to specific places and times is often problematic. For example, many teachers experience difficult access to images that illustrate specific concepts as they apply to local settings relevant for their classes. This paper proposes that GloVis (“Global Visualization Viewer”), a web-based graphic search tool available though the USGS EROS Data Center (eros.usgs.gov), provides an effective tool to illustrate geographic concepts in the classroom. This article introduces instructors to GloVis and provides a step-by-step tutorial to guide those without prior experience who may wish to use these resources in their classrooms. Applications require access to simple tools such as Microsoft PowerPoint, Microsoft Paint, or equivalents, internet access, and capability for projection within the classroom. The methods described here are suitable for illustrating applications in a variety of disciplines at several academic levels.

GloVis
GloVis [http://glovis.usgs.gov/] is designed as a search tool to support users of the USGS Landsat archive. It provides a variety of capabilities to facilitate searches of archives, which are described here to familiarize readers with its capabilities. Most readers who wish to use GloVis in support of their classroom activities will apply only a few of its capabilities for searching for and displaying their images. This discussion pertains to GloVis version 7.8, first available June, 2007.

GloVis works with a variety of popular browsers. If users experience difficulties accessing GloVis, they should be sure pop-up blockers are disabled, and “Java Runtime Environment” is installed on their computers—help and documentation resources provide specific details. When GloVis is activated, the user first sees a primary window, and then, after a short time, a secondary window opens to permits users to access GloVis imagery. Users should keep the main GloVis window open, even though they will use the secondary window to access GloVis.

Although GloVis provides access to several forms of imagery, it opens by default to display the Landsat archive, displaying Thematic Mapper (TM) imagery. Landsat TM, and other sensors, collect information in several regions of the electromagnetic spectrum—images displayed as “color composites,” formed using three of the numerous bands, usually with the brightnesses in the green, red, and near infrared regions displayed in the blue, green, and red channels, respectively. Readers who are not familiar with these concepts should consult an introductory remote sensing text such as Campbell (2007) Jensen (2007), or Lillesand and Kiefer (2004), or on-line resources such as http://chesapeake.towson.edu/data/all_composite.asp. TM imagery is indexed using the
Worldwide Reference System (WRS), a grid system in which positions of Landsat scenes are specified “Path/Row” designations, in which the Paths and Rows form columns and rows.

The user opens a web-enabled window (Fig. 1) that allows the user to select a location anywhere within the Landsat coverage area (encompassing the Earth’s land areas, excepting some Polar regions) by entering latitude and longitude, or by positioning a cursor on a world map. The GloVis Viewer opens to show nine contiguous thumbnail images of Landsat TM scenes tiled to form an array centered on the location of interest (Fig. 1). The center image outlined by the yellow frame is the “active” image, subject to the operation of the tools described below. Users can navigate by using the arrows in the box at the left to shift the active window up, down, left, right, or diagonally. Or, the user can enter latitude/longitude, or Landsat path/row designations, to shift the location as desired. On the left-hand panel, the “prev scene” and the “next scene” options allow the user to scroll through other scenes for that region that were acquired at different dates. At the left of the window, a dialogue window allows users to constrain selection of scenes to satisfy their requirements for season or maximum cloud cover. The “scene information” frame lists characteristics of the center scene, to show its cloud cover, scene quality, and date of acquisition.

The Menu Bar at the upper left of the GloVis screen allows users to access tools relevant to archival searches, and the display of results:

**Collection:** Permits GloVis users to select the sensor of choice, from a variety of imagery available from USGS archives.

**Resolution:** Allows the user to select either smaller scale (the “1000 meters” option) to display coarse detail, or larger scale (the “240 meters” option) to display fine detail. For most applications suggested here, users will prefer to select imagery at larger scale, finer detail. The resolution options vary according to the collection that the user has selected.

**Map Layers:** Allows the user to select from a variety of geographic features, including roads, political boundaries, and principal cities, which can be selected to be projected over the images displayed in the GloVis viewer. These features assist viewer navigation by providing familiar locational references.
Tools: Offers users a selection of tools; some are described in subsequent paragraphs, most are not of immediate significance for the applications suggested here.

File: Allows the user to manipulate scene lists and metadata.

Help: Provides explanations of the various tools and options available for the GloVis user.

The GloVis window opens by default to show Landsat TM scenes. As noted above, the “Collection” menu allows the user to select from a list of several sensors, including aerial photography. This capability allows users to show the same region as recorded by several sensors, at different levels of detail. For example, users can easily show an area at large scale by selecting an aerial photograph from GloVis, and represent the same area in its regional context by displaying a Landsat image of the same region. The “scene list” panel at the lower left allows users to maintain a list of scenes of interest for convenient reference.

GloVis’ Help utility, and the Quick Start Guide (http://glovis.usgs.gov/QuickStart.html), provide detailed information pertaining to use of GloVis and its full set of features. Advanced users can access features not discussed here, including the option to download source code, if they have an interest in applying all of the features offered. It is important to note that although GloVis is designed as a search tool to access the complete archive of full Landsat scenes, the applications proposed in this paper address use of the preview images in the classroom. Because preview images are configured to fulfill a purpose that differs from that proposed here, they are not perfectly matched to instructional needs. Therefore teachers should take care to match their examples to their students’ ability to understand the patterns recorded by any given image. Clearly, applications that require more subtle interpretations work best for older students and those with more experience in examining maps and imagery. Students with less familiarity with use of maps and images will learn best from images that depict key features at larger scales and sharp contrast. More experienced students can usually comprehend learning points presented at smaller scale with subtler differences in tones and colors. In either instance, use of images of regions familiar to students accelerates comprehension of content portrayed on maps and images.

The following points highlight key considerations for teachers who desire to use GloVis imagery in their classrooms:

GloVis advantages for classroom use are that it:
- offers a world-wide archive of digital imagery, spanning several decades;
- is easily accessible at no cost to users;
- can be used without special training or specialized software;
- presents content suitable to support a wide variety curricula, at a range of grade levels;
- offers imagery free of the copyright restrictions that apply to much of the imagery available using Google Earth and related sources.

Disadvantages are that:
- assignment of colors to bands is not always consistent across different images;
- users will often desire finer resolution than the preview images can present;
- preview images may be of uneven quality; the cloud cover percentages are not always correctly stated;
- search capabilities may require that users search through many scenes and/or dates to identify imagery suitable for an intended application.

Context and Related Resources

On-line resources, including GloVis, empower teachers to introduce concrete, authentic, geographic content, and to cultivate development of a geographic perspective and a geographic awareness. Most teachers, even if they are unaware of the specifics, probably understand that there is a wide variety of on-line tools that are available gratis, or at nominal cost. These resources offer a continuum of capabilities for visualization, analysis, and accessing of archived imagery. Such resources exist within a larger context of on-line resources, software systems, and educational resources available to educators. Although this paper addresses only a very narrow topic at one end of this continuum, readers may wish to refer to discussions such as those of Nellis (1994), Sui (2004) and Baker (2005), who address broader options for use of internet and GIS-related resources in the classroom.

This paper introduces teachers to the pedagogical potential of GloVis, so it will not attempt to survey the full range of capabilities offered by these resources. However, it is important to recognize related resources relevant to the capabilities discussed in this paper. Google Earth [http://earth.google.com/], perhaps the most widely known on-line resource for immediate access to aerial imagery, can offer teachers convenient access to imagery world wide,
with convenience and flexibility in navigation and display. (Google Earth provides advanced versions such as Google Earth Plus, and Google Earth Pro that provide enhanced capabilities for users.) Google Earth imagery forms a valuable resource that can be used in concert with the proposed applications of GloVis outlined here. However, in its present form, Google Earth does not offer the quality of broad-scale views offered by GloVis, nor does it provide sequential perspectives, including varied seasons, over the three-decade history of the Landsat archive, that GloVis provides.

GloVis IN THE CLASSROOM

The purpose of the paper is to inform the reader of the capabilities and potential of GloVis preview images for use in the classroom, and to provide specific examples to stimulate and inspire teachers to develop applications that more closely parallel their specific needs. Its premise is that GloVis images can enrich existing teaching resources, not by replacing existing classroom materials, or forming independent stand-alone content, but rather by offering engaging visual illustrations to support teaching of content and concepts already identified as significant learning goals.

Examples illustrate how GloVis can contribute to teaching of state standards of learning. For example, Virginia’s 2001 Standards of Learning (http://www.pen.k12.va.us/VDOE/Instruction/History/hist_11.pdf) include goals specifically focused upon content conveyed by Landsat imagery:

- Apply geographic skills and reference sources to understand how relationships between humans and their environment have changed over time; (VUS1)
- Analyze and interpret maps to explain relationships among landforms, water features, climatic characteristics, and historical events. (VS1)

Other U.S. states have similar standards that, although stated differently, depend upon related topics and concepts. GloVis imagery permits teachers to illustrate core geographic themes, such as:

- Regionalization—a common theme in grades 4-6;
- Urban growth—significance of urban systems, and urban sprawl;
- Environmental change—a common theme in state SOLs;
- Human impact upon landscape, such as urban sprawl, strip mining, logging;
- Impact of natural disasters—floods, hurricanes, wildland fires;

The value of this resource lies in its ability provide concrete visual evidence of concepts and events that otherwise must be typically presented as abstract ideas, without a local dimension. Aerial imagery, especially as historical sequences, can contribute valuable geographic and historical dimensions to these discussions. Such imagery can be especially effective when it can represent regions that are specific to a student’s locale or region, or events that are relevant to students at a personal level. GloVis contributes to teachers’ capabilities to develop multifaceted discussions in which students encounter a variety of resources, including not only aerial imagery, but maps, photographs, data, and first-hand personal accounts.

The GloVis archive forms a resource that permits instructors to examine and select appropriate images to illustrate specific concepts using resources that are available to most teachers. A teacher basically requires internet access, a screen capture utility, such as Microsoft Paint, and presentation software, such as Microsoft PowerPoint. After selecting a specific region, the user can scroll through dates to select those with the best visual qualities to illustrate the concepts at hand, and then use screen capture, and paste images into PowerPoint for classroom use. If digital projectors are not available, images can be prepared as overhead transparencies. In such a context, access to a color printer may form the biggest obstacle for teachers who do not have access to a digital projector.

One of the principal merits of the use of GloVis for teaching geographic content is its ability to provide the instructor with visual examples applicable to relevant states and regions. The following sections present seven examples of interest to teachers in several disciplines at several academic levels. (The Virginia examples presented here are intended as models for analogous content specific to other regions.) These examples illustrate also the availability of supporting information for many topics readily accessible through world wide web. Campbell (2007) offers additional examples.
EXAMPLES

Example 1-- Virginia's Physiographic Provinces

Virginia’s physiographic provinces are an important learning objective at several levels in Virginia’s educational programs. It is specifically included in Earth Sciences (E.S. 8a) portion of Virginia’s 2003 Standards of Learning (SOLs). Virginia’s Physiographic Provinces-- Coastal Plain, Piedmont, Blue Ridge, Ridge and Valley, and Appalachian Plateau are described by Woodward (2005), providing source material appropriate for use of K-12 teachers.

![Image of Virginia's Physiographic Provinces](http://www.wm.edu/geology/virginia/index.php)

Figure 2. GloVis Landsat preview scene illustrating landscapes of Virginia’s Piedmont, Northern Blue Ridge, and Ridge & Valley. The central region of the image shows portions of the Shenandoah Valley, and Massanutten Mountain. Credit for inset: Credit: The Geology of Virginia, Department of Geology, College of William and Mary (http://www.wm.edu/geology/virginia/index.php).

Figure 2 illustrates how GloVis images depict the physiographic and land use differences between Piedmont, Blue Ridge, Ridge & Valley, and Appalachian Plateau. It illustrates the positions and forms of four of Virginia’s physiographic provinces: On the left of Figure 2, Virginia’s Piedmont is the broad, undulating, surface sloping towards the east. Next, to the west, the Blue Ridge is an extensive upland extending roughly north-south, from Georgia through the Carolinas north into Virginia, formed of resistant metamorphic rocks of varied origins. The east-facing slope, known as the Blue Ridge Front, is a steep escarpment forming a distinct boundary with the western edge of the Piedmont. Further to the west lies the Ridge and Valley province, formed of sedimentary rocks, severely folded and faulted to create parallel ridges and valleys. The Ridge and Valley is recognizable on Landsat imagery as linear valleys and ridges, distinctive especially for the open, cleared land, and forested ridgelines. The extreme southwestern portion of Virginia includes a small portion of the Appalachian Plateaus, formed from flat-lying strata, highly dissected by stream erosion such that only narrow crests of summits remain to indicate the even surface.

Example 2-- Suburban Sprawl Along Virginia’s I-95 Corridor

The historical length of the Landsat archive, and consistency of the image format, facilitates illustration of phenomena that change over time. The TM and MSS archives are long enough to observe human/environmental
changes that have developed over several decades. Although Landsat’s broad-scale detail limits use to phenomena that occur over rather large areas, even at the coarse scale of the thumbnail images, GloVis provide visual evidence of the impact of both human and environmental processes as they operate over time. These images support the content covered by the lesson plans provided by Hodges (2005) (What Makes Cities Grow?), designed for use at grades 4 to 6. She discusses cities with varied growth rates, with examples based mainly upon data and thematic maps. Use of such sequential images can supplement these resources by providing concrete images that illustrate differences between growth patterns of different cities. It is in this context that the GloVis archive of several decades of sequential imagery offers teachers an especially valuable resource.

Transportation corridors connecting Virginia’s Fall Line cities have historical significance as foci for development of the urban infrastructure into continuous metropolitan systems, as described by Gottman (1961). Landsat images are effective in representing the location, extent, and evolution of urbanized regions. Figure 6 depicts the urbanized region between the Baltimore metropolitan region (at the top center of the image) and the Washington metropolitan region (in the center). Hydrographic features are prominent, especially the Chesapeake Bay, and the Potomac River and its estuary. Urbanized regions appear as the grayish tones, dense at their urbanized core, with thin, web-like threads extending outward along transportation corridors.

Figure 3. GloVis preview scenes illustrating growth in suburban sprawl along Virginia’s I-95 corridor, 1985-2006. Left: In 1985, the gray-blue tones, indicating dense urban development, form detached spots focused on urban centers. Right: 20 years later, the urbanized areas from a continuous strip centered on the I-95 transportation corridor.

The 1995 image represents urbanized regions as nodes, with distinct dense regions at their core, and tentacles radiating outward along transportation routes. Physical infrastructure is focused on localized structures. The Baltimore and Washington foci are only loosely connected. By 2005 (the left-hand portion of Figure 6) the pattern has lost its node-like structure. Here we see a more mature pattern, with a filling-in of gaps in the urbanized corridor—Baltimore and Washington are now connected by a solid connection of urban and suburbanized territory. Development has extended along new axes oriented roughly at right angles to the principal north-south transportation axis of the metropolitan structure.
TUTORIAL

The following text presents specific steps to apply GloVis to develop classroom teaching aids:

Open GloVis at [http://glovis.usgs.gov/](http://glovis.usgs.gov/). Navigate to the desired region using the world wide map, latitude and longitude, WRS path and row coordinates, or the arrows in the navigation box at the left of the screen. Set the cloud cover and quality options as desired (usually it is convenient to set the cloud cover value low and the quality option high). Once the user has navigated to the desired region, it is usually desirable to select the higher resolution option (240 m for Landsat data) to offer a more detailed view of the scene. Then, using the date section of the screen and/or the “Next Scene” or “Prev Scene” arrows, the user can scroll through the varied dates available for the region to select the season and dates that are of greatest interest.

Once a scene has been identified, the user can use Microsoft Paint, or comparable options, to acquire a screen shot of the image. Alternatively, by right-clicking on the GloVis image in the browser, the user can view a menu that will allow the user to acquire the browse image, by selecting “Show Browse,” (Figure 4). The browse image will then display in a separate window, and the user can left-click on the image to view a menu that presents the option to “Save Picture As . . . ,” or to copy as preferred.

![Figure 4. Example illustrating the menu that appears using the mouse to left-click on the GloVis browse image. This menu allows the user to save the browse image as a separate file for later use with application programs.](image)

The browse image, acquired either as a screen shot, or by saving it directly as described above, can then be pasted as an image in PowerPoint, or comparable program (Figure 5). Within PowerPoint, the user can use the varied PowerPoint options to annotate the image to highlight and label key features. Further, by selecting differing options shown within the “Collection” tab on the GloVis browser, users and select and download imagery from other achieves to supplement or illustrate selected features in greater detail, or o show a series of images at different dates. Note also that the “Map Layers” tab on the GloVis browser allows users to project locational information, such as political boundaries, road networks, and place names onto the browse images. Teachers can easily prepare the browse images, or their teaching materials as pdfs, to facilitate use by students as homework or class projects.
SUMMARY

GloVis, although designed as a tool for browsing Landsat and related remotely sensed imagery, can serve as an archive of satellite imagery for teachers to select imagery suitable for illustrating key content and concepts, especially as it might apply to regions relevant for their students. Although the preview images have coarse resolution, their detail is adequate for many classroom purposes.

GloVis provides a useful source for imagery illustrating key concepts, and broad-scale processes and events. Its ease of access assures its availability for teachers working in a wide variety of professional circumstances. The length of the archive spans several decades, so it provides a resource effective for illustrating long-term landscape changes. Further, the broad geographic scope of the archive allows teachers to select imagery illustrating regions local to their institutions. Its use is effective for illustrating phenomena that can be observed over large regions and display discrete changes.

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