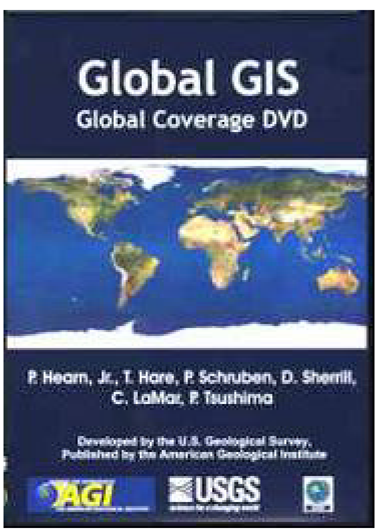
THE GLOBAL GIS PROJECT: GIS DATA AND LESSONS FOR THE WORLD

Joseph J. Kerski, Ph.D.
Geographer
US Geological Survey
Box 25056 – MS 507
Denver CO 80225-0046 USA
jjkerski@usgs.gov
rockyweb.cr.usgs.gov/outreach/

ABSTRACT

A series of educational units have been created to help researchers, educators, and students use the seven-volume set of geospatial data from the U.S. Geological Survey (USGS). The data, compiled in a project called the Global GIS project, are distributed by the American Geological Institute (AGI), on: http://www.agiweb.org/pubs/globalgis/. Information on the Global GIS Project may be found at the US Geological Survey: http://webgis.wr.usgs.gov/globalgis/ and at the AGI: http://www.agiweb.org/pubs/globalgis/description.html. The educational units, online on: http://rockyweb.cr.usgs.gov/public/outreach/globalgis/, focus on earthquakes, water resources, population, and minerals. All lessons are based on national science and geography content standards, and ask students to solve real-world problems and examine patterns, relationships, and trends in an inquiry-based setting that is fascinating to students and educators alike. The USGS Global GIS database contains a wealth of USGS and other public domain data, including global data of elevation, land cover, seismicity, and resources of minerals and energy at a scale of 1:1 million. The GIS, which is run on the included Environmental Systems Research Institute's (ESRI) ArcView Data Publisher software, is produced by region (typically a continent) on seven CD-ROMs, and also on a single DVD.

INTRODUCTION

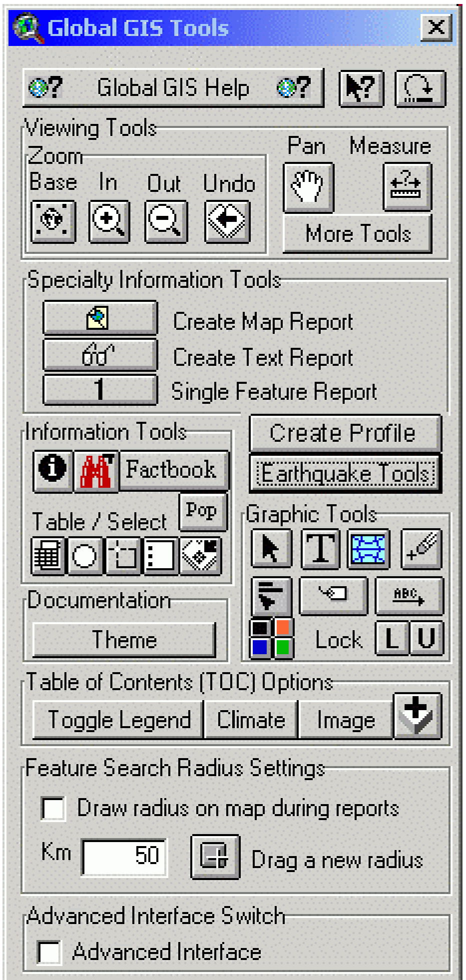


The U.S. Geological Survey (USGS) and the American Geological Institute (AGI) have partnered to make the USGS Global Geographic Information System (GIS) database readily available to educators and the general public in the form of a CD and DVD-based world atlas. The USGS Global GIS database contains a wealth of USGS and other public domain data, including global data of elevation, land cover, seismicity, and resources of minerals and energy at a scale of 1:1 million. The GIS, which is run on Environmental Systems Research Institute's (ESRI) ArcView Data Publisher software, is produced by region (typically a continent) on seven CD-ROMs and also on a single DVD (left). The Data Publisher software is included on the CDs and DVD.

Virtually all of these datasets are readily available in digital form, either on the Internet or on CD-ROM. However, most of them are stand-alone products, and, even though they are readily available, they often require specialized software access. Very few have been combined into integrated products. The GIS is built from relatively small-scale data (1:1 million scale or 1 km resolution) and placed on seven CD-ROMs (or one DVD) that are organized by regions of the world. Each CD-ROM contains data for a given region includes a user-friendly GIS viewer and set of tools. The DVD contains data for all seven regions as well as the GIS viewer and tools.

The Global GIS project combines existing global datasets, enhancing the impact of individual data products, and makes the aggregate product attractive to a larger and more diverse customer base. The

Global GIS database is designed to be used with the full version of ArcView 3.0 or higher, or the included free software, ArcView Data Publisher. Each CD and DVD contains customized ArcView tools specifically designed for the datasets, making it useful for beginners or advanced GIS users (below).



The CDs or DVD can be ordered from the American Geological Institute's web site on: http://www.agiweb.pubs/globalgis/. The media is reasonably priced for individual or classroom use. Additional information on the Global GIS Project may be found at the US Geological Survey: http://webgis.wr.usgs.gov/globalgis/ and on the AGI site: http://www.agiweb.org/pubs/globalgis/description.html.

GIS AND REMOTE SENSING IN EDUCATION

GIS and Remote Sensing (RS) are used in three major ways in courses at the elementary, secondary, and university level. First, teaching *about* GIS/RS dominates at the college level, where courses in methods and theory of geospatial sciences are taught in geography, engineering, business, environmental studies, geology, and in other disciplines. Second, teaching *with* GIS/RS is emphasized at the elementary and secondary level, where GIS in particular is used to teach concepts and skills in earth science, geography, chemistry, biological science, history, and mathematics courses. Finally, GIS/RS are used as a fundamental research tool in all institutes of higher education in environmental studies, geography, demography, geology, and other disciplines.

The U.S. Labor Secretary's Commission on Achieving Necessary Skills (SCANS) stated that the most effective way to teach skills is "in context" (U.S. Dept. of Labor 1991). SCANS competencies include identifying resources, working with others, using information, and understanding complex interrelationships. Implementing GIS into the curriculum may encourage students to examine data from a variety of fields. Early in 2004, the US Secretary of Labor identified geotechnologies (along with nanotechnology and biotechnology) as one of the "most important emerging and evolving fields" (Gewin 2004).

Since the publication of the first national content standards in geography (Geography Education Standards Project 1994), social studies (National Council for the Social Studies, National Task Force for Social Studies Standards 1994), science (National Research Council 1996), and technology (International Society for Technology in Education 2000), educators nationwide have been progressing toward a model of instruction that emphasizes a hands-on, interdisciplinary, research-based learning experience. The national geography standards state, "The power of a GIS is that it allows us to ask questions of data." Students using this inquiry approach form research questions, develop a methodology, gather and analyze data, and draw conclusions. The approach is not, "How can we get GIS into the curriculum?" but rather, "How can GIS help me to accomplish my goals in the classroom?" A growing body of research points to the benefits of using GIS to enhance student learning, despite implementation challenges (Baker 2002, Doering 2003, Kerski 2003).

A growing body of exciting educational units have been developed by educators, for educators, at all levels since the early 1990s that help students examine their world using GIS. These include over 130 lessons on ESRI's ArcLessons site www.esri.com/arclessons, and recent books of standards-based lessons and data by ESRI Press entitled *Mapping Our World* (Malone et al. 2002) and *Community Geography*—

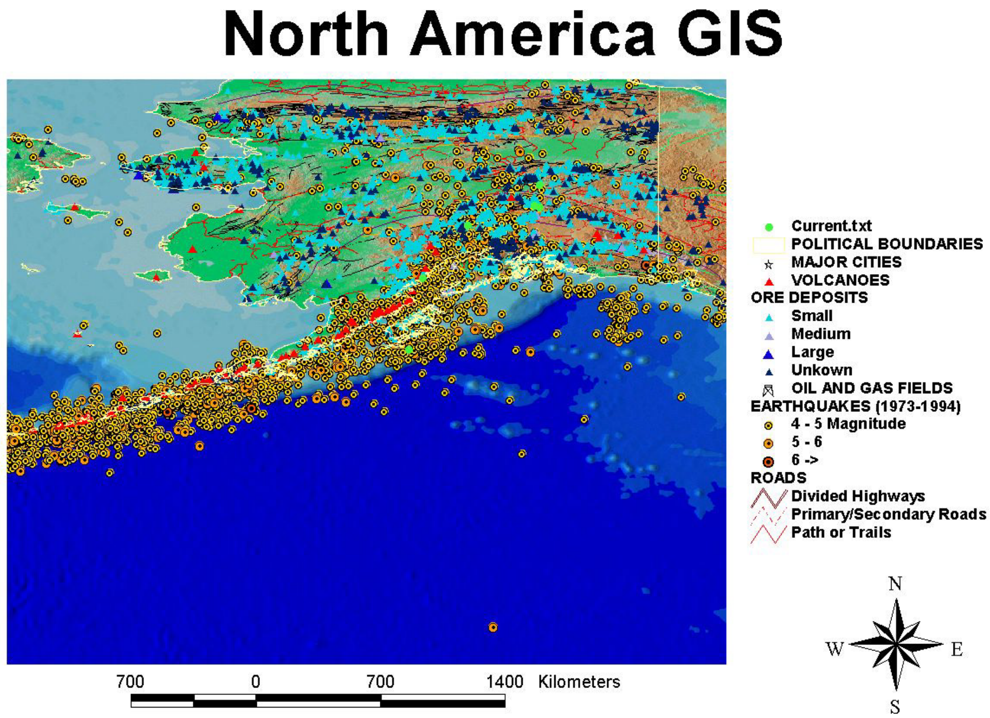
Teachers Guide (Malone et al. 2003). Other resources include three books that use GIS to explore earth science topics on the dynamic earth, tropical cyclones, and water resources from Thomson Brooks-Cole Publishing on http://www.brookscole.com/earthscience_d/, the Mapping The Environment curricula developed by Dr. Bob Coulter of the Missouri Botanical Garden on www.mobot.org/education/mapping/index.html, lessons, data in online, CD, and DVD formats, and online courses from TERC on www.terc.edu. The Orton Family Foundation has developed a Community Mapping Program (www.communitymap.org) that uses geospatial technology to empower students and communities to actively participate in planning their futures. A series of GIS-based lessons from the US Geological Survey have been developed on rockyweb.cr.usgs.gov/public/outreach/. All of these resources use GIS and RS as a tool to investigate climate, population, watersheds, land use change, landforms, tornadoes, political geography, earthquakes, ocean currents, historical settlement, hurricanes, and much more.

INVESTIGATING THE PLANET VIA THE GLOBAL GIS PROJECT

The first units created for the Global GIS project focus on North America and Europe, but the questions they contain about earthquakes, water resources, population, and minerals can be applied to any region. The emphasis of the Global GIS units is to take something that is of interest to students and use it as a focal point of inquiry about the Earth. Instead of starting with a topic such as map projections or seismicity, why not start with a topic that the students have natural curiosity about, and build the lesson from there? For example, in the North America earthquakes Global GIS units, students are asked to investigate the location and characteristics of the most recent earthquakes near the community in which they live, within the scenario that they are working under contract for the US Geological Survey. Through the lessons, they realize that almost every location has seen *some* earthquakes in the past,. In addition, if earthquakes are not the predominant natural hazard in their community, they are asked to consider what other hazards exist, and why they are important.

Using maps, understanding the physical and human characteristics of places, how physical systems affect human systems, and applying geography to interpret the past are some of the national geography standards that the units address. The units address national social studies standards of time, continuity, and change; and people, places, and environments. The units address national technology standards of how to gather, synthesize, and process information, as well as national science standards by analyzing ocean currents and climate.

The Global GIS units include student lesson sheets, assessments, and answer keys. The units are designed for university and high school students. Hundreds of short answer and fill-in-the-blank questions address multiple learning styles. The step-by-step lessons guide the students through parts that require using the GIS software. The units are written for ArcView 3.x GIS, but the data sets can be used in ArcGIS and in other GIS software. In addition, the units themselves can be modified for use in other GIS software. In the earthquake unit, for example, students progress through the activities in nine parts. In part one, “What’s Shakin’?”, students examine earthquakes across North America, noting their distribution, magnitude, and depth, and then examine specific regions on the continent, such as Alaska and California (below).



In part two, “Digging Deeper,” students examine the relationship between earthquakes and cities, and investigate earthquakes in a specific area in California. In part three, students investigate the Loma Prieta Earthquake of 1989, one of the worst earthquakes ever to strike the United States, assess critical infrastructure, and assess the relationship of fault lines to earthquakes. Students assess their own community’s vulnerability to earthquakes using in part four. In part five, “Earthquakes Everyday,” students analyze this week’s earthquakes from the USGS National Earthquake Information Center on the Internet. In the next part, they map new earthquakes within the GIS environment, and compare them to historical earthquakes. In part seven, “Earthquakes Respect No Boundaries,” students determine how many earthquakes occurred in each country through advanced GIS querying.

Students are initially presented with the following scenario: The U.S. Geological Survey was created in 1879 to help understand the geologic, biologic, hydrologic, and geographic characteristics and phenomena of the planet. Included in this mission is a thorough understanding of earthquakes. To help assess where and why earthquakes occur in North America, the U.S. Geological Survey has hired you as an earth systems scientist to provide them a report that will include the distribution, frequency, and causes of earthquakes in North America, specific regions of the continent, and the state where you attend school. Included in the report must be an analysis of the depth and magnitude of the earthquakes, and the locations and characteristics of cities, volcanoes, and faults in relationship to earthquakes.

Earthquakes cause millions of dollars of property and critical infrastructure damage each year. "Critical infrastructure" refers to large-scale systems that local, regional, and national governments build across the landscape. These include roads, airport runways, power lines, gas pipelines, water pipelines, sewer lines, railroads, fiber optic cable, broadband Internet lines, telephone lines, shipping docks, power stations, radio and television transmission towers, and canals. Students are asked to list three kinds of critical infrastructure that could be destroyed or damaged during an earthquake. For each, they are asked to describe why the destruction of these infrastructure resources is so disruptive to local, regional, and national government and commerce.

After viewing an earthquake animation, the students are asked: What years do the earthquakes cover? USGS seismologists want the students to make three observations about the spatial pattern of earthquakes that you notice as they occur across the North American continent. Students consider the extent of the earthquakes, and specific areas of North America where earthquakes occur more often, and make three observations about the magnitude of earthquakes and where earthquakes of certain magnitudes occur across North America. They are asked if large earthquakes only occur in specific regions, and if so, where? They also determine if any specific years seem to have more earthquakes than others, if more earthquakes occur near oceans or in the interior of the North American continent? They compare the number of earthquakes that occur in the oceans versus land, and earthquakes in the Atlantic versus the Pacific Oceans. They examine the mid-Atlantic ridge and reflect on the hazard that exists to people when an earthquake occurs in the ocean. They assess the part(s) of North America where people need to be most concerned about earthquakes occurring in the ocean. Next, students turn their attention to volcanoes, making three observations about the pattern of volcanoes in North America, and determine the relationship of earthquakes and volcanoes. Next, students determine, though tabular analysis, how many earthquakes are recorded during an average year, find the largest and deepest earthquakes in the table and on the map.

Next, students zoom to the western side of the United States to the area of California and read the following scenario: You receive an email from the USGS seismologists that ask you to determine four major areas of California where most earthquakes occur. What four areas will you list in your report? Turn on major cities and turn off earthquakes. You might have to zoom in to see the labels. Zoom to the center of the Pacific Coast of the United States, central California and Nevada. Use the "Create Profile" tool and draw a line from Carson City, Nevada, southwest to San Francisco, California. Describe how the land elevation changes from Carson City to San Francisco. Examine earthquakes along the profile. What kind of terrain is more prone to earthquakes—valleys or mountains? Why? Of the six major cities in California, indicate in your report to the USGS the two cities that you consider to be the most vulnerable to an earthquake. Indicate why you consider them to be the most vulnerable.

In a different section of the unit, students determine how many earthquakes are within 50 kilometers of major cities, and assess the earthquake risk of these cities. Students also examine the relationship of earthquake intensity and depth to the proximity of fault lines and plate boundaries. Instead of being *told* that different types of plate boundaries witness different numbers of earthquakes, they *discover* this for themselves by interacting with the data.

For the Europe earthquakes unit, students focus on the Mid-Atlantic Ridge, examining earthquakes along the ridge and in Iceland. They also investigate earthquake “zones”, a historical earthquake—the Lisbon event of 1755, and a modern-day earthquake—the Turkey event of 1999. This illustrates the versatility of these units—they can be adjusted to fit each region of the world.

The population unit includes sections where students examine the relationship of landforms, hazards, climate, land use, and vegetation to population. They uncover the relationship of population to transportation routes, coastlines, and rivers, and why urban areas grew where they did. They are invited to examine current growth rates and assess population pressure on the environment in the region.

The watershed unit invites students to consider the fact that we are all using a shared resource, and that geography matters. In the minerals unit, students explore the spatial pattern of minerals, how they are related to the geology of the region, and minerals’ effect on watersheds, the location of cities, and transportation routes.

Sprinkled throughout the unit are many “why?” questions. In answering these questions, students do not simply click menus and buttons, but reflect on their answers. Students are also challenges to become familiar with and be critical of the data they are using. They come to the realization that their answers are highly dependent on the quality of the data sets they are using, and the scale at which they are examining.

At the end of the unit, students indicate what they consider to be the most surprising thing they have learned in this part, the most interesting thing, and the most significant thing. They are asked to indicate at least three things that they have learned about the phenomenon in the region they are studying, and at least three things that they have learned about GIS. Finally, they are asked to give a presentation on the phenomenon to their class, school, or community group. In the case of earthquakes in North America, the presentation must include:

(1)--Why earthquakes are a serious international natural hazard.

(2)--Where earthquakes occur in North America.

(3)--The relationship of cities, volcanoes, fault lines, and other features to earthquake epicenters.

(4)--How GIS can aid in analyzing earthquakes and other spatial phenomena.

(5)--What they recommend that the national and international community do about earthquake preparedness.

Summary

The advantages to using GIS/RS over printed maps, tables, and books is that students can analyze maps within a GIS at an infinite variety of scales, create their own maps based on latitude and longitude coordinates and other instructions, analyze data tables that represent the attributes of mapped features, analyze earth images that show landforms and river drainages, and quickly synthesize a large amount of data about the Earth to make an informed decision. GIS enables all of these problems to be examined at the correct scale, helps students consider "what-if" scenarios, allows students to create their own data, and enables students to become geographic investigators. Equally important, students are used to learning on the computer, and are engaged in the process of interacting with computerized maps in a way that paper maps cannot offer.

GIS is used as one tool, but not the only tool, in investigating the Earth. In the units, students read and analyze text, diagrams, web sites, mathematical equations, and other data outside of GIS. This illustrates how GIS can effectively be used with other methods of instruction. As students progress through the units, they are encouraged to think about the patterns and relationships they uncover. Many answers are not found by clicking a button on the computer, but through the geographic inquiry process. Geographic inquiry includes asking a question, gathering geographic information, investigation, discovery, analysis, and asking new questions. If these topics can be investigated using GIS, there is no limit to how GIS and RS can help students become the geographic thinkers we need to address tomorrow's problems.

Obtaining the Resources

The best way to purchase copies of the Global GIS CD-ROMs is from the AGI Online Bookstore at http://www.agiweb.org. The CD's are available for $29.95 each, or all seven CD-ROMs for $180. The Global Coverage DVD-ROM costs $149.95. All educational site licensing permits unlimited educational and research use of the GlobalGIS products for the licensed users. To order or if you have questions, contact AGI Publications Licensing at: pmdorr@agiweb.org or (703) 379-2480, extension 216. For a computer lab, a license for up to 50 concurrent users may be purchased for instructional use, for $50 for each CD-ROM, and $250 for the DVD-ROM. An unlimited K-12 Lab/school-wide license exists for research and instruction in a single K-12 school at $100 for each CD and $500 for the DVD, for fewer than 500 students, or $125 for each CD and $625 for the DVD for over 500 students. For a university license of fewer than 100 faculty, staff, and majors, the price is $125 for each CD or $625 for the DVD, and $175 for the CD and $875 for the DVD for a campus with over 100 students and faculty.

ArcView Data Publisher 3.1 works in Windows NT 4, Windows 2000, or Windows 95/98/ME/XP and requires an industry-standard PC with a Pentium microprocessor, at least 24 MB of RAM (64 MB recommended), and 34 MB hard disk space (600 MB recommended).

REFERENCES

Audet, Richard H. and Abegg, G.L. 1996. Geographic information systems: Implications for problem solving. *Journal of Research in Science Teaching* 33(1), 21-45.

Baker, Thomas R. 2002. The effects of Geographic Information System (GIS) Technologies on students' attitudes, self-efficacy, and achievement in middle school science. Ph.D. Dissertation. The University of Kansas, School of Education. 204 p.

Doering, Aaron H. 2003. GIS in education: An examination of pedagogy. Ph.D. Dissertation. University of Minnesota.

Geography Education Standards Project. 1994. Geography for Life: National Geography Standards.

Washington, DC: National Geographic Society, 272 p.

Gewin, Virginia. 2004. Mapping Opportunities. *Nature* 427(376-377). 22 January 2004. Nature Publishing Group.

International Society for Technology in Education. 2000. National Education Technology Standards for Students. Eugene, Oregon: ISTE, 373 p.

Kerski, Joseph J. 2003. The implementation and effectiveness of GIS technology and methods in secondary education. *Journal of Geography* 102(3): 128-137. National Council for Geographic Education.

Malone, Lyn, Anita M. Palmer, and Christine L. Voigt. 2002. *Mapping Our World—GIS Lessons for Educators.* Redlands, California: ESRI Press, 525 p.

Malone, Lyn, Anita M. Palmer, and Christine L. Voigt. 2003. *Community Geography: GIS In Action—Teachers Guide.* Redlands, California: ESRI Press, 152 p.

National Council for the Social Studies. 1994. Curriculum Standards for Social Studies. Washington, DC: NCSS, 178 p.

National Research Council. 1996. National Science Education Standards. Washington, DC: National Academy Press, 262 p.

U. S. Department of Labor. 1991. Secretary's Commission on Achieving Necessary Skills (SCANS). Washington, DC: GPO.