1 Building Earth Data Resources into DLESE

Compiled by
Bruce Caron *et al*
for the DLESE Quality
Workshop 2004[1]

A White Paper from:
DLESE Data Access Working Group [DAWG]; together with: DLESE Data Services; Using Data in the Classroom

1.1 Background

Using Data in Undergraduate Science Classrooms
Cathryn A. Manduca and David W. Mogk.
Final report on workshop funded by NSF:
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April 2002

While DLESE has long been focused on accumulating earth science educational resources that are of high value and relevant in diverse educational settings, the past year has seen a new emphasis on bridging between data (and model)-rich earth science research and earth science education. This paper focuses on the issues and problems surrounding data access, and how these impact data use in the classroom and by the public.

A primary work outlining the problematics and potentials in this area was the report *Using Data in Undergraduate Science Classrooms* (http://serc.carleton.edu/files/usingdata/UsingData.pdf). This report

1. In collaboration with many DLESE and DLESE Data Access Working Group (DAWG) members, including Tamara Ledley, LuAnn Dahlman, Cathy Manduca, Dave Mogk, Ted Haberman, Anupma Prakash, and Bill Prothero. This version of the White Paper was vetted at the 2004 DLESE Quality workshop in Santa Fe. Bruce Caron is the Chair of the DAWG.
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Image above: the Blue Marble from NASA's Earth Observatory website (http://earthobservatory.nasa.gov/Newsroom/BlueMarble/)

is based on an interdisciplinary workshop where the problems and the promise of bringing real data resources into the classroom were discussed at length. The conclusions of this report begin with the following: "WORKING WITH DATA IS ONE OF THE MOST EXCITING ASPECTS OF UNDERGRADUATE SCIENCE EDUCATION for students and faculty alike. There is broad consensus that using data in the classroom is an important component of education in all the STEM disciplines for philosophical, pedagogical, and practical reasons. Data-rich environments support inquiry- and discovery-based learning, which in turn allows students to participate in, and better understand, the conduct and products of science [emphasis in the original]."

Today, DLESE stands at the forefront of the NSF digital library effort for the geosciences, and has emerged as the logical home for many earth science services that the NSDL may not choose to provide, given its science, technology, engineering, and mathematics (STEM)-wide scope.

Digital Library for Earth System Education

Since 2002, the outlook for access to earth data resources for undergraduate classrooms and other educational settings has been slowly improving through the efforts of many persons and organizations. From federal agencies and organizations (such as the NSF, NASA, NOAA, and the USGS) to universities and non-profit organizations (notably, the ESIP Federation, the GLOBE program, and the Open Geospatial Consortium [OGC]), several ongoing efforts that share the goal of bringing data-rich science experiences to students and the public are being met by early adopter educators who are looking to build the curricula that can support data use. The DLESE Data Services group and several NSDL projects (such as the Earth Exploration Toolbook, the Data Discovery Toolkit and Foundry, and THREDDS) exemplify the current state of the effort.

While the challenges of using data in the classroom are many and varied, here we shall focus mainly on the challenges of data access and the tools that needed to handle data once this has been accessed.

In the past several months, DLESE has become an active forum for advancing the use of data in the classroom. The effort to include data (and model/visualization) resources in the digital library will require that new types of collections be considered. This effort entails all of the issues that DLESE now faces (e.g., content quality, appropriate metadata, interface usability, pedagogical effectiveness, and capacity building). While the challenges of using data in the classroom are many and varied, here we shall focus mainly on the challenges of data access and the tools that needed to handle data once this has been accessed.

1.2 Overview

"One of the services implicit in the NSDL as a digital library is the promotion of public 'data literacy.' NSDL users will need to acquire the ability to visualize and analyze digital resources made publicly available through the NSDL."

Manduca, Cathryn, Flora P. McMartin, and David W. Mogk, eds. March 20, 2001. *Pathways to Progress: Vision and Plans for Developing the NSDL*.

We all live in an increasingly data-filled world. Schools and universities require data-rich tools to teach data and information technologies and science. Consumers need to understand how data and information affect their daily lives. Today, experts use high-level commercial software products (with extensive learning curves) to create the images of data that we see on the Internet or on television. Commercial data tools are designed primarily for forefront research and graduate-level work. Although they offer powerful data handling capabilities, their complex user interfaces limit their applicability in secondary schools or beginning undergraduate classes.

In its formative *Pathways to Progress* white paper (March 20, 2001), the NSDL outlined the scope and need for new user services and tools. One of the needs is that of promoting "data literacy:"

> It is valuable to remember that the NSDL is more than a digitized library. The NSDL exposes its users to vast holdings of digital information resources, such as the terabytes of data stored at government archives. Some of these resources include data sets that require visualization and analysis in order to be used. Today the data are delivered via the Internet mostly through derived images, which still require interpretation. Soon technologies will extend the visualization of these data to the user's desktop. This delivery capability presupposes that the user will know what to do with these data.
>
> One of the services implicit in the NSDL as a digital library is the promotion of public data literacy. NSDL users will need to acquire the ability to visualize and analyze digital resources made publicly available through the NSDL. The Services track will promote data literacy through software tools that bring data visualization and analysis capability to the user, and through informational and instructional content development about digital data and information interpretation and use. The NSDL, as a next-generation of digital libraries, will need to accommodate the next generation of data-savvy library users (NSDL 2001; http://nsdl.comm.nsdl.org/meeting/archives/smete/meetings/grantees0901/whitepaper.pdf).

Building library resources to support new generations of data users was a founding need for the NSDL: a need that was, and remains, most acute in the geosciences. Today, DLESE stands at the forefront of the NSF digital library effort for the geosciences, and has emerged as the logical home for many earth science services that the NSDL may not choose to provide, given its STEM-wide scope.

1.2.1 A challenge for all national digital libraries

National Science and Technology Council IT2 Working Group. 1999. *Information Technology for the Twenty-First Century: A Bold Investment in America's Future.* Proposed in the President's FY 2000 Budget.

One goal that national digital libraries face is to put real data at the center of tomorrow's curriculum by "[b]uilding an 'electronic information exchange' [that] will allow every American to retrieve text, data, visual, and other information in a wide range of subject areas (IT2 Working Group Report 1999, 11)." With terabytes of new earth data entering national data archives every day, expanding the use of these massive (and expensive) data resources represents a national need at many levels. DLESE is at the center of this effort due to the particularly data-rich research environment of earth system science.

President's Information Technology Advisory Committee. February 1999. *Information Technology Research: Investing in Our Future: The President's Information Technology Advisory Committee Report to the President.*

In its report to the President, the President's Information Technology Advisory Committee noted that "[One] of the challenges a National Digital Library presents [is]: Interfaces that let users visualize and understand the wealth of available information (1999, 42)." The technical architecture for these interfaces is still being designed and redesigned as data formats and standards emerge and middleware resources (such as THREDDS and OPeNDaP[1]) develop.

At the two ends of the earth data access challenge are the archives and the public. In the middle are the teachers and the user application developers.

At the two ends of this national data access and use challenge are the data archives and the public. In the middle are teachers and technicians (e.g. campus educational technology staff or third-party developers) who are designing and crafting digital solutions for the classroom and the public. Teachers who want to incorporate more/better data resources into their curriculum usually do not have the technical expertise to build these interfaces—but they have learning content to contribute. Staff technicians and third-party developers may not have a firm picture of the pedagogy, but they have skills in application authoring tools.

Additionally, neither teachers[2] nor application developers can currently be expected to have the skills needed to access earth data resources. Earth data access skills remain mostly in the province of

1. The Thematic Real-time Environmental Distributed Data Services (THREDDS) is a data cataloging NSDL service project based at UNIDATA (http://my.unidata.ucar.edu/content/projects/THREDDS/index.html). OPeNDaP is a server-side data handing layer for subsetting and data integration (http://OPeNDaP.org/). Formerly called DODS, it has received support from NASA and the US Navy.
2. Teachers here refers to the great majority of teachers at all levels, including even to earth science specialists when they are looking for data resources outside their own area of research. Similarly, application developers here refers to software programmers who use common authoring environments for educational applications (Java™, Macromedia Flash™, Macromedia Director™, Visual Basic™, etc.).

earth science researchers. Access by these dedicated users has been built into the levels of service required of the data archives by their contracts.

Public[1] access is also a requirement for the government archives (DAAC[2]s). Today, the public may be able to locate the data ordering page on a DAAC website. Success in actually ordering and using the data still requires that the user knows how to answer fairly technical questions about the data (For Example, See Footnote 1 on page 10 below) and then also know how to input and manipulate the data on (mainly) commercial software applications.

1.2.2 DLESE has several on-going data access efforts

Above: image from Using Data in the Classroom home page

Clearly, the process of developing data-rich interfaces represents a multi-person, multi-skill, and multi-perspective team effort. How does DLESE help these teams develop and find the resources they need to succeed? There are several efforts within the NSDL/DLESE community that are building solutions to this problem. Among these are the following:

- DLESE Data Services
- DLESE Community Services Center
- DLESE Data Access Working Group (DAWG)
- THREDDS
- Using Data in the Classroom
- Earth Exploration Toolbook
- Starting Point
- Data Discovery Toolkit and Foundry (DDTF)
- DLESE community meeting strands (past 2 years)
- DLESE membership in the ESIP Federation

These efforts are described in greater detail in Appendix ii, below.

How can DLESE leverage value from these [data access] efforts? How do data-access issues impact other efforts in DLESE?

Perhaps the new Data Services effort within DLESE signals DLESE's focus on educational earth data use issues and answers. At this point, however, DLESE as an organization and as a community still needs to achieve a working understanding of the data access situation and also of how improved data access would impact earth system education at all levels and settings.

1. The "public" for earth data and earth science includes international partners and peoples. Even though NSDL and DLESE are national efforts, they are addressing issues that are global in nature. The underlying rationale of the earth systems approach is that it has no geographic bounds.
2. Digital Active Archive Center (DAAC) applies to both NASA and NOAA archives. The NASA DAACs have created the DAAC Alliance (http://www.earth.nasa.gov/data/daac/). NASA and NOAA DAACs are also members of the ESIP Federation.

DLESE needs to develop clear policies about including data resources, and a vision of how teachers will use these resources within diverse educational settings.

DLESE needs to examine its current data access efforts and their funding and plans, so that it can begin to build a strategic effort to reach its data access and data use goals in earth system education. How can DLESE leverage value from these efforts? How do data-access issues impact other efforts in DLESE? How can DLESE develop clear policies about including data resources, and a vision of how teachers will use these resources within diverse educational settings?

1.3 Earth Data are Not Easy

Much of the current effort to facilitate data-access for earth system education is required simply to work-around a thicket of issues and obstacles surrounding data access and use. The bulk of these issues occur relatively close to the data archives; these are issues such as metadata, cataloging, inventory, file formats, and subsetting. Other issues arise significantly in the user-arena, particularly in K-12 settings, where curricular requirements have been constructed without data access (mainly because of a history of a lack of access).

1.3.1 The chicken AND the Egg problem

The petabytes of data available from NASA and NOAA DAACs have been typically used by earth science researchers and others with long-term data access needs, skills, and resources.

The data access "system" for education has been negatively impacted from both ends: from supply constraints to a lack of capacity. The problem has not been "the chicken or the egg" but rather, "the chicken *and* the egg": both sides are problematic. The petabytes of data available from NASA and NOAA DAACs have been typically used by earth science researchers and others with long-term data access needs, skills, and resources (from grad students to expensive commercial software licenses). These users have created their own pathways to the data they need[1].

Even these power users find areas of potential use where serious problems remain. The need for both coverage information and inventory information across archives is one area of common complaint. Data on, say, sea-surface-temperature, is available from more than one DAAC. Each DAAC has its own inventory of these data which covers certain areas of the oceans. And the data may have been collected from one or more instrument sensors (e.g., AVHRR or MODIS).

Still other complexities arise: The original data files may be stored as records according to the orbit number of the satellite. The resolution of the data may be different according to the sensor used. Different science teams may process the data into different projections and file formats (e.g. HDF-EOS and GeoTIFF), and use different

1. The analogy of the brier patch and the rabbit comes to mind. The perennial users of earth data have, through diligent efforts, created hidden runs through the thickets. But newcomers are bound to be scarred by the gorse.

processing algorithms.

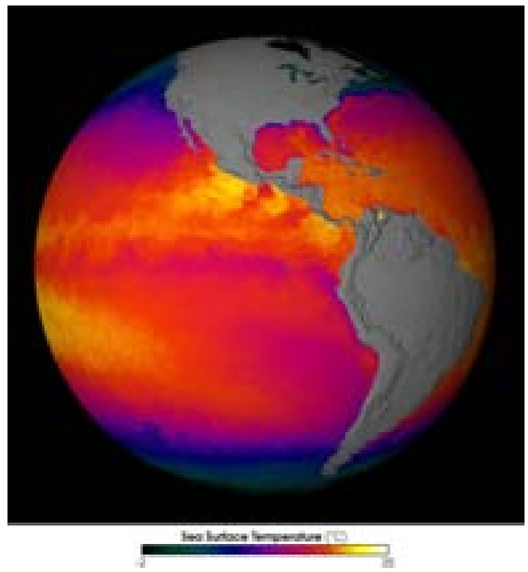


Image: sea surface temperature from NASA's Visible Earth website: (http://visibleearth.nasa.gov/cgi-bin/viewrecord?11834) "A new sensor orbiting the Earth aboard NASA's satellite is now collecting the most detailed measurements ever made of the sea's surface temperature every day all over the globe. Like a sophisticated thermometer in space, the Moderate-resolution Imaging Spectroradiometer (MODIS) is helping Earth scientists advance studies of how our world's oceans and atmosphere interact in ways that drive weather patterns and, over the long term, define our climate."

Acquiring the data from the DAACs may involve a complex series of orders for overlapping data resources, and the resulting data files may be large (hundreds of gigabytes). The commercial software needed to read the data file formats is also difficult to learn and use, and often quite expensive (although most companies offer real discounts for students[1]). The need to georeference the data and the remaining issues of resolution and time differences between data sets, etc., add complexity and uncertainty to data use.

Additionally, the same sensor output data will be made available in different forms. Level 0 data are the "raw signals"; Level 1 data are data are data that have undergone limited processing and quality control to remove system errors introduced during data acquisition. Then there are various sorts of data products; level 2 data includes scientifically validated data products that are routinely (automatically) produced to represent data such as earthquake epicenter maps or displacement maps. Finally, Level 3+ data would require expert technical processing of the data (e.g. tomograms). Browse images of the data are another example of highly manipulated data output.

Some of the complexity is "wired" into the task of remote sensing observations (multiple satellites, multiple sensors, etc.). Some of the complexity is built into the administration of government agencies. And some of the complexity is a result of the residue of pioneering technological efforts at data delivery from the time before the Internet (these are commonly referred to as "the legacy[2]" and the horror-movie overtones at times seem apropos).

Today, data archives still struggle with issues of scalability, prov-

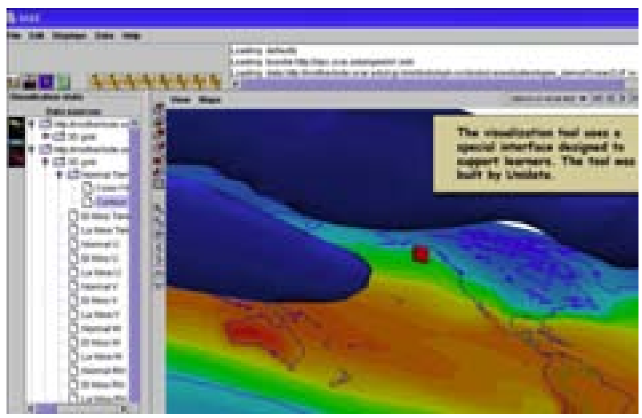
1. Data access shareware and freeware developers, usually university-based (and NSF or NASA supported) are struggling to provide data access capabilities and tools to students. These tools offer alternatives to commercial software products for certain uses and users.

enance, and persistence. Tensions over the utility of standards and data formats (e.g. HDF) imposed in the past and new standards emerging from data use communities (such as the OGC) have yet to reach a functionally adequate solution.

Even the seasoned data user may spend weeks creating a reliable access path to a new data resource.

For decades, science researchers and other long-term data users have cobbled together access maps and technologies (e.g. MATLAB™, IDL™, or ArcGIS™[1] scripts) that connect them to the data resources with which they are familiar. But even the seasoned data user may spend weeks creating a reliable access path to a new data resource. Accessing earth data may never be easy, however, much can be done to make this far less difficult, far less complex, and far less uncertain than it is today.

1.3.2 Reaching out to earth science educators



Commercial tools, while certainly powerful, tend to be overly complex for students or teachers. With NSF support, new, education-friendly user applications are emerging. Unidata has been developing user-side technologies that are appropriate for education. The VGEE viewer is one such technology. The NSDL Data Discovery Toolkit and Foundry is another. Source: http://www.unidata.ucar.edu/content/Presentations/UPCsemseries/VGEE.pdf.

DLESE seeks to reach its widest end-user population of earth science learners through providing digital content that earth science teachers and organizations want to use. Much of the discussion during the past five community meetings has been aimed at facilitating the needs of educators. DLESE collection metadata reflects the concern about matching content to the educational use situation. The DLESE portal has been designed to help teachers find content appropriate to their classroom. And teachers come to DLESE to find content that has been reviewed for quality, linked to standards (in K-12), and combined with curricular use infor-

2. The original protocols designed to manage data resources in the early 1970s reflect the hardware, software, and networking constraints of the period. When NASA pioneered the delivery of earth data, personal computers would not appear for another decade, with the Internet still another decade in the future. When data systems age, the data they hold needs to find a way to migrate to new systems. A new generation of data archive technology (e.g. the data grid) is now emerging.
1. MATLAB™, IDL™, and ArcGIS™ are examples of data handling commercial software products that offer users powerful tools to access, visualize, manipulate, and analyzed data. This power comes with a learning curve that requires something of a career move to accomplish. These software products are usually introduced at the advanced graduate student level of work, although early adopter teachers have been experimenting with the use of ArcGIS in high schools.

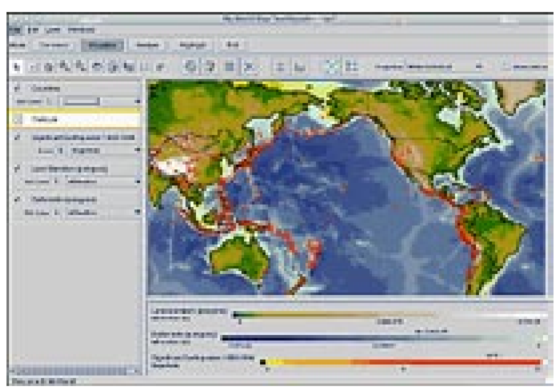
mation.

As much as DLESE is concerned about the quality of its content, it is also concerned about the quality of the user experience. Even the best earth data/model resources are problematic unless they offer the teacher enough support for these to be implemented and explored in their classroom (See Also: Appendix i: Data Sites that Support Effective Educational Use, below). Often there are concerns about the availability and then the appropriateness (in terms of grade level and graphical user interface [GUI] complexity) of the user-side software available to view and manipulate earth data.

1.4 User-Near Data Applications

"User-near" applications ask, "What do you want to learn today?"

Teachers should not have to be data-access technicians. Rather, data access should be built into software applications in a seamless manner. The NSF has supported earth data application development efforts through CCLI and other funding (particularly NSDL)[1]. Starting with the idea that the best graphical user interface (GUI) is one that is invisible, intuitive, and elegant, educational application developers are now working to assemble reusable code GUI objects (behaviors and graphics) and learning objects. The goal is to foster the creation of "user-near" earth data-rich applications through the creation of a community-based code development efforts that share resources.



At Right: A *My World* software screen display. *My World* is a Geographic Information System (GIS) designed specifically for use in middle school through college classrooms. *My World* provides a carefully selected subset of the features of a professional GIS environment... The features are accessed through a supportive interface designed with the needs of students and teachers in mind. [source: http://www.worldwatcher.northwestern.edu/myworld/index.html]

"User-near" data rich applications are custom designed to allow the student to access that data that are necessary for the lesson, and the tools necessary for the learning task. "User-near" applications ask, "What do you want to learn today?" Commercial data handling applications are decidedly "user-far." They are designed to serve the largest population of users with the largest range of needs. These applications ask "How many

1. Among these are the IDV project at UNIDATA (http://my.unidata.ucar.edu/content/software/idv/index.html), the GEODE program at Northwestern University (http://www.worldwatcher.northwestern.edu/myworld/), Earth Education Online at UCSB (http://oceanography.geol.ucsb.edu/Index.html), and the Data Discovery Toolkit and Foundry (http://www.newmediastudio.org/DataDiscovery/index.html).

different types of data do you want to handle, and how many different operations do you want to do?" These qualities are precisely what high-end researchers have asked for. But they are precisely the wrong design for educational use.

The Global Change Master Directory (GCMD) is NASA's main user community data portal (http://gcmd.gsfc.nasa.gov/). The GCMD learning center page: (http://gcmd.gsfc.nasa.gov/Resources/Learning/)

The current data access web pages also tend to be "user-far", at least when educators attempt to use them. The pages that DLESE does point to, such as the GCMD Learning Center page, offer mainly data images and unreviewed[1] links to the actual data. More often than not, the actual data download task will require information and skills that almost no non-earth science researcher will control.

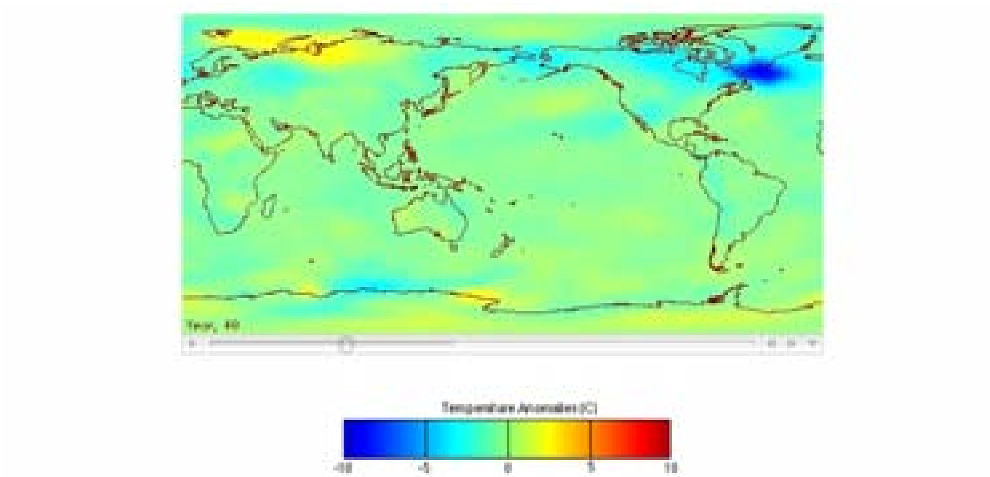
While there are many (and sometimes, perhaps too many) websites that offer teachers *images* of data, it would be difficult to point a teacher at many actual earth data files ready for classroom exploration. However, this situation can change, and DLESE is positioned to be a catalyst for this change.

1. For example, links that may require special knowledge of the data before the user can reliably order these. The GCMD learning center links to a page for AVHRR data with the following instructions: "The Pathfinder data are processed as 32-bit floating point numbers to maintain maximum accuracy. In generating the output data, each layer is scaled to an appropriate 8-bit (unsigned) or 16-bit (unsigned) integer value corresponding to the ranges shown in the table below. Consequently, to obtain the geophysical values from the scaled data value, offsets must be subtracted from the scaled data value and the result multiplied by the gain. Complete information on scaling and bit representations are provided in the table below. [spelling corrected from the original]

Parm.	bits	Offset	Gain	Bin. min/max
NDVI	8-bit unsigned	128	.008	3 / 253
Ch1	16-bit unsigned	10	.002	10 / 50010
Ch2	16-bit unsigned	10	.002	10 / 50010
Ch3	16-bit unsigned	-31990	.005	10 / 36010
Ch4	16-bit unsigned	-31990	.005	10 / 36010
elev	16-bit unsigned	15010	1	10 / 25010
lat	16-bit unsigned	9010	.01	10 / 18010
lon	16-bit unsigned	18010	.01	10 / 36010
lsm	16-bit unsigned	0	1	0 / 2

"

Source: ftp://daac.gsfc.nasa.gov/data/avhrr/global_8km/



2 Earth Education with Rich Data Access[1]

2.1 Putting Earth Data on the Desktop

The goal of bringing earth data to students and the public in a manner that facilitates learning and builds an understanding of the role of data and models in earth science and the value of earth data in comprehending earth system dynamics can be achieved through new efforts addressing three main needs. These needs are: 1) to build thematic data collections of appropriate size and with adequate semantic metadata to made the data discoverable; 2) to create user-side data-handling software that is both powerful and easy to learn and use; and, 3) curricular development to integrate data resources into the classroom setting. Looking at these three needs and how they might be filled, we can begin to see where DLESE can play a pivotal role.

1. Model output is another source of “data” for students. Applications that allow students to run models and evaluate their output help bridge between research and education.
“Modeling an abrupt climate change- Animation of surface air temperature change.
This animation shows the annual mean surface air temperature difference from the long-term average (red/ orange is warm, blue is cool, and green indicates little change) during the 200 years of the model run. During the first 100 years, an external source of freshwater was added to the North Atlantic at a rate of 10^5 m^3/s, simulating a discharge of meltwater into the North Atlantic. This results in a reduction in the thermohaline circulation that causes a cool region to develop and intensify southeast of Greenland (dark blue). The cool region is well developed and intense in years 50-100....”[Animation programmed by the DDTF NSDL project]
(Source: http://www.ncdc.noaa.gov/paleo/abrupt/model_animation.html).

2.1.1 *Building thematic collections*

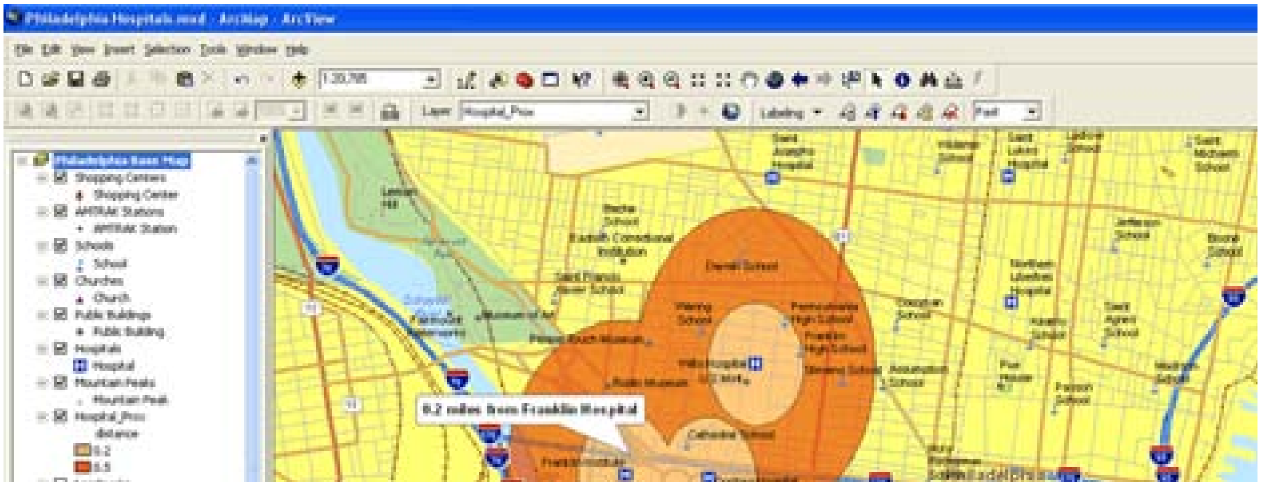
Educators will need earth data that are accurate, persistent, concise (small downloads only) and on topic. To create these resources, collection developers will need tools to browse and select from existing data archives, and to add metadata to the data. Collections will need to be hosted and maintained on the Internet. The topics for the data collections will need to match the curricular needs of the teachers. The data would need to be in a format that data viewer software can read; and the data metadata should be in a form that is concise and understandable to diverse users (See: Appendix i).

2.1.2 *Developing user tools*

Users tools can be either Internet-based or stand-alone on the desktop. They should be "user near" and geared to the educational setting. They should not expect that the user will know where to go to get the data, or how the data are specified. They should promote active manipulation of the data and an awareness of data display knowledge (data literacy). They should be linkable to reusable learning objects and other curricular content.

2.1.3 *Capacity Building and Curricula Development*

Educators will need to first imagine how incorporating rich data resources into their earth science classes will affect learning and the student's understanding of the content. Working with curriculum developers, educators will need to articulate how earth data resources will fit into their teaching load, and develop the content that will help situate data resources and tools within the overall learning process. Specific data requests should be communicated with the collections and tool builders. Thematic data should be delivered from websites that promote their effective use (See: Appendix i). It is important that earth data not be indiscriminately released to classrooms and the public without providing an appropriate context for understanding and interpreting the data. Data literacy will need to be a national goal that touches the "expert" and the public alike.



3 Data access within the Scope of DLESE[1]

3.1 Issues, Concerns, Recommendations

DLESE and the NSF (with help from other government agencies) have an opportunity to break through to real data use by creating and supporting data access partnerships inside and outside of DLESE.

3.1.1 *A Work Plan for Current DLESE-Sponsored Activities*

There are some currently active projects that might be tasked to pursue DLESE data access objectives. Additional work might require new priorities and future support to reach the threshold of significant use that would advance the national goals for data use through the digital library. With Data Services acting as coordinator, the current activities might look to new objectives. Here is a short list:

DLESE needs to have a home for data access.

DLESE needs to enable users to discover the data they require.

- Develop the Using Data in the Classroom (Using Data) portal as a core portal to all DLESE held metadata describing data sites, data tools, and data rich activities.
- Experiment with and test faceted search vocabularies within the Using Data Portal to refine discovery of data, tools and activities and to explore the ability to convey the match between the sites and tools and the criteria for supporting effective educational use.

1. GIS applications bring geographical information and analysis capabilities to maps that help teach students to think spatially. ESRI has been a leader in building commercial GIS solutions. "There is a vast difference between visualizing data in a table of rows and columns and seeing it presented in the form of a map. ArcView provides... options for creating production quality maps.... With ArcView you can also visualize data in the form of charts and reports, in 3D, and over time." Source: http://www.esri.com/software/arcgis/arcview/about/overview.html

DLESE needs to have a review process for data sites.

- Move forward with vetting and adoption of the description of data sites that support effective educational use. Extend its content review processes to include data, leading to quality assurance for educational data and products (See: Appendix i, below).

DLESE needs to help bridge between data sets and curricular content.

- Support strong linkage between data sites, data rich activities, and information that supports effective teaching with data. The EET and Starting Point (http://serc.carleton.edu/introgeo/) projects are examples of this effort. DLESE Data Services and Community Services are working to facilitate this.

DLESE needs to support the developers of user applications and data-rich Internet sites.

- Provide reusable resources for developers of both data sites and teaching materials that enhance their ability to create excellent resources for students to learn from data. First steps in this direction are collections of resources for developers on the Using Data site; the development by the DAWG of design principles (e.g., using a pattern language model); and articulation of a clearer model of the variety of pathways, people and mechanisms that transform data from collection to the classroom. DLESE data services workshop should be part of this as well as the survey of data use.

DLESE can play a coordination role for efforts to understand learning with data. Already, DLESE efforts in the earth data use are extending our understanding.

- Continue studies that enhance our understanding of how faculty and teachers find and use data including how faculty teach with and students learn from data. Efforts in this area include the data services study/survey of data use; The Using Data in Undergraduate Classrooms report on faculty use of data; Cutting Edge survey on teaching methods and web use; the NSDL study of digital library use; and, the Using Data work on discovery and vocabularies.

3.1.2 DLESE can be the home for quality earth data

Funding Needs: This service would require funding in the $100k range to set up, and could be reasonably maintained.

As with most of the content at which DLESE points its users, DLESE does not own this content, but adds value through the metadata and review processes. The freely available earth data resources as a whole have entered the multiple petabyte size (a petabyte is a million gigabytes). Yet the need for small, reusable *thematic* data sets was announced several times at the recent DLESE Community meeting, and the prospect of DLESE (or a partner with data hosting experience) housing these data was also suggested. With disk storage costs as low as they are today, DLESE could create (or subcontract) an earth data education resource that offers several terabytes of data files (each file would be a few megabytes) that could feed much of the earth data access needs for educators. These data would be of high quality, with topical significance to teaching earth system science at different levels, and would be maintained through durable URLs.

3.1.3 DLESE can lead a team of content and application developers

Funding Needs:
New NSF support in the range of $500k-$1m per year will help create a robust delivery network through DLESE, and then fill this with valuable and reusable data and applications.
DLESE is positioned as the logical nexus of both support and content hosting for educational earth data resources. Current data access solutions need to be supported while new solutions for emerging needs need to find support.
The NSDL is no longer supporting earth data delivery projects it once funded.

DLESE should use existing solutions where possible to deliver these value-added data collections to students. New projects can fill in gaps in existing efforts, or replace those that are not chosen to be sustainable (See also: Appendix ii). Many of the enabling technologies and capabilities are ready to be tasked to fill this need, but will require support and coordination:

- THREDDS provides a means to author and distribute thematic data collections;
- OPeNDaP provides server-side subsetting and other utilities that make it possible to build specific data collections out of larger data resources;
- The Data Discovery Toolkit and Foundry (DDTF) offers application authoring tools that can quickly build simple, powerful applications customized to the particular data set and educational setting;
- The DLESE Community Services Center is developing exemplars of effective use of data and data products in a variety of instructional settings;
- The ESIP Federation (of which DLESE is an active member) can facilitate access to data at government archives.
- The Earth Exploration Toolbook (EET) service brings together data resources with curricular support, and;
- Using Data in the Classroom is a central site to support data use by teachers at all levels

The DLESE Data Services workshops are already bringing together data providers, application developers, curriculum experts, and teachers to create exemplar data/model resources. This team can coordinate the DLESE data access network effort. DLESE can also support data access developers by creating a core portal for their code and other resources (as recommended by the DAWG). The Using Data in the Classroom portal effort can be expanded to support authoring environments as well as teacher needs.

Beyond DLESE proper, earth data delivery needs to be articulated as a goal of the NSF, and encouraged through the proposal process. Reuse of data products and services created through the CCLI and other grants needs to be a requirement for funding, and a reuse center built into DLESE.

3.1.4 DLESE can be an active partner in articulating metadata standards

Funding Needs:
Through workshops and some staff support, the creation and testing of a DLESE data metadata standard can be completed in two years for less than $150k. The resulting 3rd-party metadata collection will need to be hosted and maintained.

Metadata for DLESE data, whether internal or linked from an external collection, needs to be semantically well described to allow non-specialists to access these data. But DLESE might serve its users better by working within a larger framework of metadata efforts. DLESE and the DAWG and Data Services team should work together with the ESIP Federation, the Open Geospatial Consortium, the Federal Geographic Data Committee (FGDC), the International Organization for Standardization (ISO), and others to achieve a metadata standard for educational use. This standard should allow implementation through OPeNDaP and THREDDS subsetting and data collection efforts. The semantic metadata should be created and then hosted as a "3rd-party" solution that can be expanded for multiple languages and other special needs. This effort might be best managed by the ESIP Federation, with active participation by DLESE.

The NSF and the Division of Earth Sciences should encourage funding recipients who are generating data to create metadata compliant with the DLESE metadata requirements.

3.1.5 DLESE can help coordinate NSF's (and NASA's) data use capacity building efforts

DLESE is the most visible and the most prepared organization to coordinate many of the capacity-building efforts that government agencies support for earth science data use.
Funding Needs:
This effort will need to be explored further as a coordinated program in order to develop an effective funding strategy.

Capacity building efforts by the NSF and NASA for earth science are vital to the goal of bringing earth data to education. This program should include studies that enhance our understanding of how faculty and teachers find and use data, including how faculty teach with and students learn from data. Current/recent NSF funded activities in this area include the DLESE Data Services study/survey of data use; the *Using Data in Undergraduate Science Classrooms* report; the Cutting Edge survey on teaching methods and web use; the NSDL study of digital library use (just funded); and the Using Data work on discovery and vocabularies. NASA continues to support the ESSE (Earth System Science Education program to improve the curriculum for earth science at the college level.

Earth data needs and uses dwarf those of most other STEM areas. DLESE is emerging as a program that can assemble the expertise and the community support to increase our understanding of data use in the classroom, and our national capacity to use these resources.

3.1.6 What falls outside of the DLESE effort?

As has been seen above, some of the work of building DLESE's data access capabilities needs to be envisioned, planned, and executed outside of DLESE proper. The larger earth science research engine that the NSF and NASA (and other agencies) support on an annual basis, needs to have a DLESE-aware facet. The tools for turning research data into educational resources could be located in DLESE, but used much more broadly.

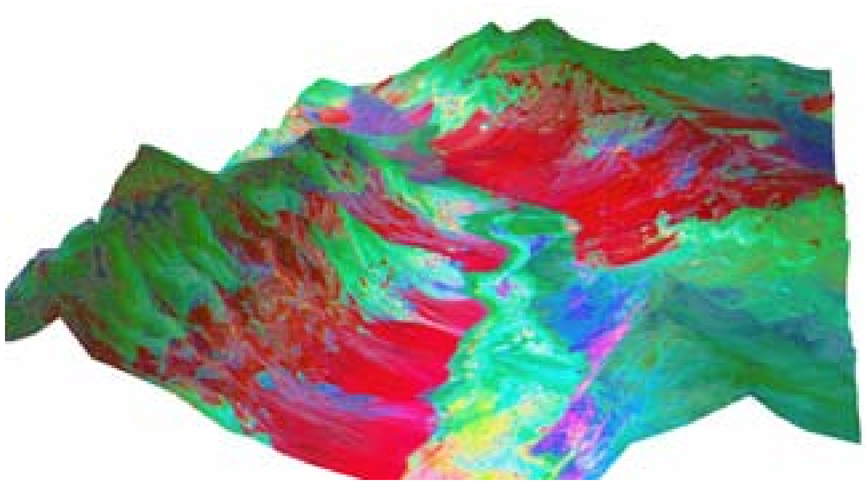
There are many data collection practices that happen before the data are available to be molded into thematic collections (e.g., scientific validation). Other practices, such as metadata standards, require wider community support, where DLESE is one of several participants. Commercial and other application developers should have access to DLESE data resources to foster a wide range of application development without DLESE/NSF support.

There is a profound difference between making data available to the public and making data generally usable by the public. This level of service needs support from the government agencies that produce and archive these data.

It is most often the case that data providers have developed their systems for a specific, highly technical clientele. Many data providers are willing (or mandated) to make their data public, but it's a huge extra effort on their part to really make the data accessible for general use. This is often viewed as an unfunded mandate, and is beyond the scope of the mission or charter of the data providers. The NSF can lead the effort to create a cultural change that demonstrates that there is tremendous value added when data are more broadly used either in education or by the public. It should be in everyone's best interest to work towards this goal. So, the data providers need help (and resources) to build user interfaces for broad use in addition to meeting the needs of their technical audiences.

3.1.7 The bottom line

Earth data access is a national (and global) need, an educational priority, a learning engine, and the key to teaching the next generation of earth scientists. DLESE must find the means to add data and data-viewing application development support within its library.



i Appendix: Criteria for Data Sites that Support Effective Educational Use[1]

1.1 Introduction

DLESE has developed and refined a strong set of criteria for defining excellent teaching activities. This document puts forth a complementary set of criteria for the broad range of data-related resources that support teaching about the Earth system but are not in themselves activities. These include but are not limited to data, data access portals, data visualization tools, data visualizations (including maps and images).models, model data and visualizations, data processing sites, data location sites. They employ a wide range of approaches to deliv-

1. This list was compiled after the recommendations of the data, visualizations, and models (DVM) strand at the 2004 DLESE meeting. Modified from version (dated 7/29/2004) edited by Sean Fox, Cathy Manduca, and Dave Mogk. This version will be sent to the DAWG for comment and recommendations back to DLESE.
Above: "This 3-D perspective view looking north over Death Valley, California, was produced by draping ASTER nighttime thermal infrared data over topographic data from the US Geological Survey. The ASTER data were acquired April 7, 2000 with the multi-spectral thermal infrared channels, and cover an area of 60 by 80 km (37 by 50 miles). Bands 13, 12, and 10 are displayed in red, green and blue respectively. The data have been computer enhanced to exaggerate the color variations that highlight differences in types of surface materials. Salt deposits on the floor of Death Valley appear in shades of yellow, green, purple, and pink, indicating presence of carbonate, sulfate, and chloride minerals. The Panamint Mtns. to the west, and the Black Mtns. to the east, are made up of sedimentary limestones, sandstones, shales, and metamorphic rocks. The bright red areas are dominated by the mineral quartz, such as is found in sandstones; green areas are limestones. In the lower center part of the image is Badwater, the lowest point in North America." Source: http://asterweb.jpl.nasa.gov/gallery/gallery.htm?name=DV.

ering information including different technologies for delivery and communication, different kinds of content and levels of data processing, and different approaches to describing and annotating their information For example, all of the following would be considered data sites:

a) Source for data, available via ftp, an OGC web service, OPeNDaP, etc.

b) A data location site such as the Global Change Master Directory

c) (http://gcmd.nasa.gov/)

d) the front page of a site that allows online data exploration directly through the web browser (using any number of techniques/tools/protocols behind the scenes to deliver the experience to the user).

   a. A portal such as the Significant Earthquake Database (http://www.ngdc.noaa.gov/seg/hazard/sig_srch_idb.shtml)

   b. A processing site such as IRI/LDEO Climate Data Library (http://ingrid.ldeo.columbia.edu/index.html)

   c. A rendering site such as a Live Access Server http://ferret.pmel.noaa.gov/NVODS/servlets/dataset

e) a page explaining the nature of a small dataset with links to download it in CSV form or as a GeoTIFF.

f) a page with Quicklime animations of time series evolution of some data.

1.2 Data Site Criteria

1.2.1 Data site allows educators and students to find and access appropriate data of interest easily.

- Level of prerequisite knowledge for use is clear
- Interface is well-designed to support querying to answer applicable scientific questions
- Semantically transparent metadata enable data discovery

1.2.2 Data site allows educators and students to ascertain the quality of data and determine the impact of data quality on the certainty of their conclusions.

- The DVM is presented in such a way that an educator will likely draw correct conclusions about its accuracy/limitations.
- Information is provided about overall data collection, quality, reduction, and limitations. Data site includes sources of error and limitations of collection process as well as inaccuracies/uncertainties from models/ particular choice of representations.
- Information about accuracy of individual data sets/points/ analyses is provided

1.2.3 Data site supports students ability to manipulate data to answer questions

- By using data contained within the site
- By combining data within the site with data from other sites
- By generating appropriate visualizations
- By compare student's own data to that in the site

1.2.4 Use of the dataset by non-experts is supported

- Information is provided on relevance of data to problems of significance
- Support for effective pedagogic use

1.2.5 Robustness of access

- Data and software needed for use are reliably available
- Tools needed for access and use are easily acquired and inexpensive
- Tools are reliable and easy to use
- Data are archived appropriately for persistent access

ii Appendix: Current DLESE and NSDL initiatives[1]

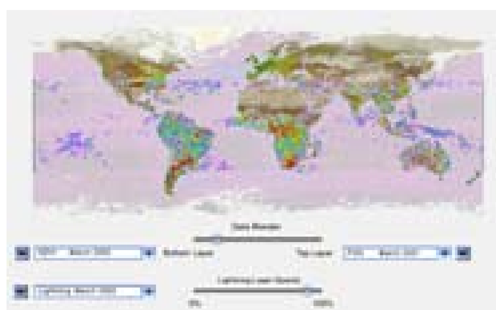
2.1 Significant Efforts on Which to Build

DLESE/NSDL already has initiatives working to meet all three needs. Here are some[2] of these efforts.

2.1.1 DLESE Data Services

DLESE Data Services (http://www.dlese.org/people/info_dataservices.html) is working to facilitate the effective use of earth system science data, visualizations, and model results by the educational community. In order to accomplish this, a number of activities are underway.

On the Right: At the May 2004 Data Services workshop a new "user-near" data tool was designed by the DDTF to bring interactive data discovery to a new EET chapter based on Normalized Difference Vegetation Index (NDVI) and lightning data provided by the Earth Observatory.



The DLESE Data Services is conducting needs assessments to identify the earth science data needs and interests of educators at all levels (http://swiki.dlese.org/DataSvcsWkshp-04/uploads/16/PhaseIResults.doc), to identify what education products that use data are available and make them available through DLESE, and to better ascertain the effective features of data interface design.

DLESE Data Services is also organizing a series of workshops to facilitate the use of earth science data and data analysis tools in secondary, undergraduate, and graduate education. The first of these workshops was held in May 2004 (http://swiki.dlese.org/DataSvcsWkshp-04/1). Participants learned about the various methods of data access and their advantages and disadvantages, and participated in discussions addressing both the technical and educational aspects of improving earth science data access and effective use in

1. "Current" also includes projects funded in the past five years that may not be currently funded.
2. If you know of a project that was not included, please contact the DAWG, and we will revise this list.

education. Workshop participants, representing the roles of data provider, tools developer, scientist, curriculum developer, and educator, also worked together in small groups to learn about each others interests and needs, and to develop an educational module in the form of an Earth Exploration Toolbook (EET, http://serc.carleton.edu/eet) chapter using the earth science data and tools represented in the group. Future workshops are planned for the spring of 2005 and the winter of 2006.

2.1.2 DLESE Community Services Center

The DLESE Community Services Center is developing a series of exemplars of educational uses of digital databases. Student- and teacher-friendly interfaces are being built to provide easy access to databases, and to provide educational contexts of how the databases can be appropriately used. Instructional resources include thematic collections of tutorials, examples, and activities that are designed to promote inquiry- and discovery-based learning.

Initial projects include websites that demonstrate an Earth system approach to integrating data and observations on the topics of "All Things Cretaceous" as an example of an interesting time in Earth history, and "Exploring the Yellowstone Geoecosystem" as an interesting place in the Earth system. Another website, "Geoscience Education in the New Cyberinfrastructure: Examples from EarthChem, EarthRef, and MELTS" provides step-by-step instructions on how to use these geochemical databases, examples of model output, and a series of increasingly sophisticated instructional activities.

The DLESE Community Services Center is also exploring ways in which students and instructors both use and contribute to collections of digital resources. An undergraduate course on "Native American Lands and Resource Exploitation" will develop a series of case studies to document the geology, physiography, hydrology, and resource base of Native American lands, and the subsequent environmental and cultural impacts of exploitation of these resources. Students will develop the case studies from existing digital data sources, and the case studies themselves will then become data-rich instructional resources. A GIS-based exercise on geology and human health will access diverse databases (e.g. from EPA, CDC) to allow students to assess local environmental health risks in communities.

Future projects will engage cyberinformatic projects such as GEON, CHRONOS, and EarthScope. These demonstrations of teaching and learning in a data-rich environment by the DLESE Community Services Center is part of a larger initiative to support the integration of research and education in the geosciences.

2.1.3 DLESE Data Access Working Group (DAWG)

The DAWG is a group of data access veterans who are charged with tackling issues that affect DLESE's data delivery effort. The DAWG coordinates its efforts with and provides advice to the DLESE Data Services team, and is supported by the DLESE Program Center. The DAWG meets once a year and works via E-mail and SWIKIs (http://swiki.dlese.org/dawg/1) between meetings.

The DAWG is searching for the right method to characterize best practices and heuristic patterns in the data delivery stream from the DAAC to the student's desktop.

At the November 2003 meeting, the DAWG finalized a set of issues that the DAWG (and DLESE) might productively pursue:

1. Facilitate discovery across distributed data archives;
2. Provide tools to help instructors and learners parse, process, and visualize datasets;
3. Facilitate the integration of seemingly disparate datasets;
4. Facilitate the development and dissemination of educational content that utilizes datasets and datastreams, and;
5. Review and update the goals that will be integrated into the activities of the DLESE Data Services.

At the May 2004 meeting, the DAWG made its first formal recommendation to DLESE:

Resolution from the Data Access Working Group to DLESE [finalized June 25, 2004]

> To facilitate DLESE as a place where participants with varying expertise can work together to create finished products that will ultimately become part of the collection, DLESE should provide a clearly-identified repository for production materials including data, metadata, draft educational modules as well as analysis and visualization tools that are under development.
>
> To avoid frustration on the part of DLESE users seeking finished, reviewed educational products, this production environment should be clearly identified as such. The DAWG will move forward on this by implementing a prototype of such a system on the Using Data in the Classroom portal, (http://serc.carleton.edu/usingdata/index.html).

The DAWG will be meeting again in the Spring of 2005. Issues that are raised by the DLESE Community and by DLESE staff and workshops will be added to the agenda.

2.1.4 THREDDS

"Inquiry is a multifaceted activity that involves... using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results." *National Science Education Standards* [http://www.nap.edu/books/0309053269/html/index.html] quoted from Domenico [http://jodi.ecs.soton.ac.uk/Articles/v02/i04/Domenico/].

The mission of THREDDS is for students, educators and researchers to publish, contribute, find, and interact with data relating to the earth system in a convenient, effective, and integrated fashion. Just as the World Wide Web and digital-library technologies have simplified the process of publishing and accessing multimedia documents, THREDDS is building infrastructure needed for publishing and accessing scientific data.

THREDDS primary technological focus is on building middleware that will facilitate the interoperability of data provider systems and the data analysis and display systems used by the communities working with the datasets. These systems are largely built according to standard protocol specifications and tools for implementing those protocols.

2.1.5 Using Data in the Classroom

"Engaging students in using data to address scientific questions has long been an integral aspect of science education. Today's information technology provides many new mechanisms for collecting, manipulating, and aggregating data. In addition, large on-line data repositories provide the opportunity for totally new kinds of student experiences. This site provides information and discussion for educators and resource developers interested in effective teaching methods and pedagogical approaches for using data in the classroom." http://serc.carleton.edu/usingdata/

Engaging students in using data to address scientific questions has long been an integral aspect of science education. Today's information technology provides many new mechanisms for collecting, manipulating, and aggregating data. In addition, large on-line data repositories provide the opportunity for totally new kinds of student experiences. The Using Data in the Classroom portal (http://serc.Carleton.edu/usingdata) provides access to the full spectrum of resources educators need to incorporate take advantage of these new opportunities to data rich activities in their teaching while supporting developers of data access, tools and curriculum with ideas, information, and resources.

Conceived as a community project, the site uses community contributions to aggregate:

- Links to and descriptions of tools and data sources for accessing and manipulating data.
- Links to on-line activities using data to teach geoscience and science concepts.
- Examples of ways educators currently use data in their courses and classrooms.
- Scenarios describing ways in which educators would like to use data in the future.

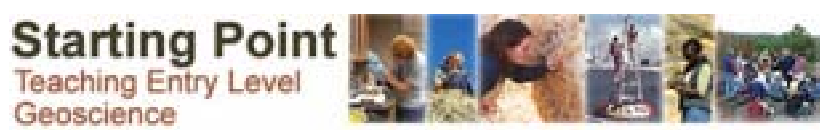
- References to scholarly work and other pedagogic resources that address practical aspects of using data in the classroom.

Community-based events have made large contributions to the collection: The 2002 NSDL Using Data in the Classroom workshop initiated the site and served as the basis for discussions of issues and methods in teaching with data; the 2002 NAGT On the Cutting Edge workshop "Using Global Data Sets in Teaching Earth Processes" developed the core of the data/tools collections; participants in an Illustrated Community Discussion at the 2003 Geological Society of America Meeting contributed descriptions of activities.

The portal also provides access to teaching materials and pedagogic information developed by the NSDL Earth Exploration Toolbook and Starting Point projects. Current work focuses on enhancing the collections, the users ability to navigate through them, and the linkages between pedagogic information, teaching materials, and data resources.

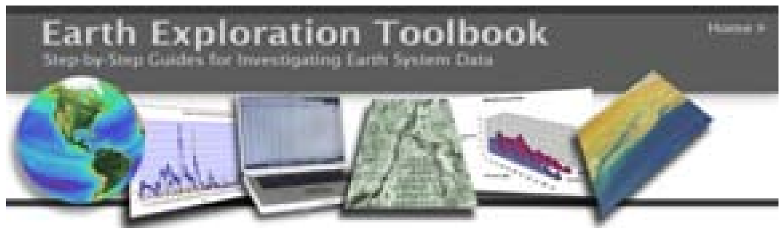
A special goal of this site is to provide information for those developing data access and manipulation tools that will help them create resources well-suited for educational use. Educators from a wide variety of community forums have contributed their insight on what makes data effective for them in the classroom. These insights have been aggregated into a set of high-level recommendations, detailed discussion and further highlighted by a set of illustrative scenarios about what educator aspire to in their use of the data. A set of intermediate products bridging the gap between data providers and curriculum developers is under development. Together these elements provide a road map for data and tool developers who want to make their work more accessible and effective for educators.

2.1.6 Starting point



Aimed specifically at faculty teaching entry level geoscience courses, the Starting Point web-site (http://serc.carleton.edu/introgeo) bridges the gap between information about teaching methods and the everyday experiences of geoscience faculty by providing geoscience specific arguments and examples. In every case, the site tries to provide all of the information needed for a faculty member or graduate student to make an informed decision about the methodology that they use in a particular teaching situation, and to implement a technique easily and well. The site has extensive materials on teaching with data and teaching with models, as well as a section on teaching field labs and is actively developing new materials in these areas. Site content is authored by faculty editors and draws on teaching materials contributed by a wide variety of individuals and projects as well as those published in the Journal of Geoscience Education.

2.1.7 Earth Exploration Toolbook



Over the years, many tools, datasets, and other resources have been developed for facilitating scientific research efforts to understand the processes that shape the earth system. However, these tools and datasets have tended to be far too complex and poorly documented, rendering their use, by anyone other than the originating scientific research team or other scientists in the field, extremely difficult. The Earth Exploration Toolbook (EET, http://serc.carleton.edu/eet) was developed to meet the growing need for access to these earth science datasets and data analysis tools, and supports their use by the broader educational community.

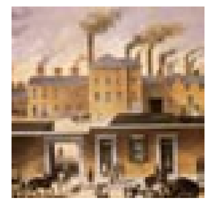
Data and other multimedia learning resources are presented together in EET chapters along with "recipes" for data use and classroom exercises. At right: an illustration from the DDTF Hurricane Science Education Center, which is being evaluated for inclusion in the EET. http://www.newmediastudio.org/DataDiscovery/Hurr_ED_Center/Hurr_Structure_Energetics/Hurr_Struct.html

The EET is a collection of chapters that provide step-by-step instructions for using earth science datasets and scientific tools in educational settings. Each chapter features specific datasets and analysis or visualization tools embedded in a compelling story, and provides enough experience and in-depth knowledge of the dataset and tool to enable an educator to use them directly, apply them to other teaching contexts, or help students use them to explore and investigate aspects of the earth system. EET chapters will encompass a variety of software tools and datasets. Currently EET chapters involve users in investigating earthquakes using GIS, exploring climate change and the relationship between stream flow and precipitation using a spreadsheet application, and examining satellite data through image analysis.

The Earth Exploration Toolbook has been designed as a professional development resource for educators. To facilitate their effective use by educators each chapter provides scientific background information and reference National Science Education Standards. In addition, educators can participate in two-hour teleconference workshop (http://serc.carleton.edu/eet/workshops.html) during which they explore the benefits of NSDL and DLESE and work through a chapter of the EET together with colleagues across the country.

2.1.8 Data Discovery Toolkit and Foundry (DDTF)

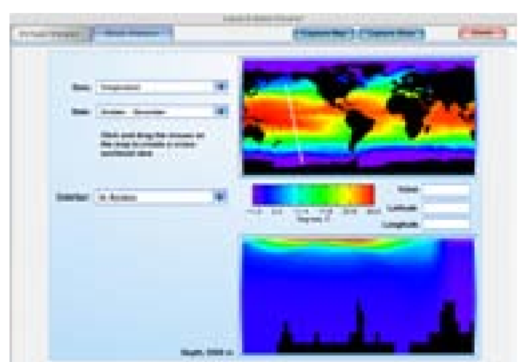
The Foundry works by finding solutions through existing software efforts, and combining these into authoring applications for educational modules. The Foundry technology uses custom plug-ins that connect already widely used high-end research data tools (such as IDL™) to the multimedia authoring environment of Macromedia Director™ (currently version MX 2004). Suddenly, an authoring software that could only read GIFs, JPEGs, and RealMedia can also read and analyze earth data (NetCDF, HDF, etc.) (Foundry picture source: Library of Congress).



Since 2001, The New Media Studio (TNMS) has led an NSDL project, the Data Discovery Toolkit and Foundry (DDTF), which serves the needs of students for simple and powerful applications that bring real data to their desktop, and the needs of the nation for improved data literacy. The goal is to accelerate the development of a broad spectrum of data (and model) rich software applications within and for the NSDL and DLESE—applications that offer high-end, research-level model and data access and visualization capabilities to education users across STEM disciplines, at all levels and any setting. Substantial progress toward this goal has been made, with high-level code resources and run-time licenses made available to the NSDL. Because of the Foundry, the NSDL is now connected end-to-end with petabytes of data and the user tools for students to access and manipulate these.

Foundry members join the Foundry because they want to help teachers who are frustrated trying to explain models and data through pictures instead of numbers and visualization tools. This is why the Foundry is linked into the NSDL Using Data in the Classroom project, where the tools are combined with exercises and science background information.

On the Right: a Foundry application that provides an interactive, 3D viewer for the entire NOAA 1998 World Ocean Atlas. This is available from the ESIP Federation eCommerce site for a cost -recovery basis ($7) and can be freely copied for educational use. (See also: http://www.newmediastudio.org/DataDiscovery/FindTOP.html)



With Foundry-built tools, students can run model simulations and plot the outcomes, or they can retrieve real-time data from the Internet and visualize and analyze these. These data can be connected to other services and data through the Internet, but the data are available for visualization and analysis using the desktop CPU—with the same tools that researchers use, only without the software learning curve.

2.1.9 DLESE Community Meetings and Strands

On the Right: DLESE community members learn about the process of data-rich application development at the 2004 DLESE Community Meeting workshop.

DLESE community meetings are venues that bring data providers, curriculum developers, and education users together. With the associated workshops, these meetings have become sites of learning about and planning for the future of data access in DLESE.

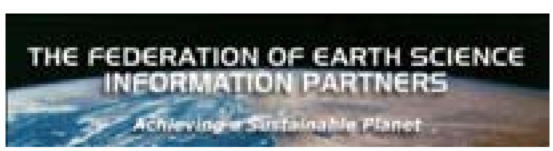
At the 2004 DLESE Community Meeting the Strand on Data, Visualizations, and Models made the following recommendations to DLESE:

- Develop data/visualization/model [DVM] quality criteria and get Steering Committee approval
- Develop the Amazon-like user feedback system and get Steering Committee approval
- Develop a review process that makes use of the DVM criteria and incorporates incentives to encourage review
- Encourage a robust communication process among developers and users that results in increasingly useful, high-quality DVM
- Develop metadata and metadata framework for DVM
- Develop an easy-to-use DVM specific UI appropriate for the diverse DLESE community

Earlier meetings also encouraged DLESE to foster data use—community input that helped the NSF to determine the need for the Data Services team in DLESE.

2.1.10 DLESE membership in the ESIP Federation

DLESE staff and leaders are welcome to participate at all levels of the Federation. DLESE Data Services PI, Tamara Ledley is currently the vice president of the Federation. DLESE DAWG Chair, Bruce Caron, is a past ESIP president. The ESIP Federation sponsors a non-profit (501 [c]3) organization, the Foundation for Earth Science, which works to sustain the efforts of the Federation.



After some years of negotiation, DLESE has joined the Federation of Earth Science Information Providers (ESIP). The ESIP Federation, sponsored by NASA's Earth Science Enterprise as a means to help its many contractees work together, is emerging as a leading community organization for earth data use. ESIP Federation membership offers DLESE many advantages: a forum where DLESE leaders can meet with data providers (e.g., DAAC managers) from NASA and NOAA; an opportunity to leverage outreach efforts through the ESIP Federation education and community engagement committees; access to the work in progress of emerging resources from NASA contractees. Similarly, DLESE offers the Federation a digital library where its data products and services can be evaluated and then found by a diverse user population.

Most of the issues and problems of earth data access are being addressed by one or more of the ESIP partners, and DLESE can help shape the future of earth data access by providing feedback from its users to this effort.