# SCIENCE INFORMATION SYSTEMS NEWSLETTER



## *Office of Space Science*

## Science Information Systems Program

Read the latest on NASA's information systems

www-sisn.jpl.nasa.gov

**34**

# Welcome to Issue 34

***1994***

## Features

**Page**



## Departments



*The NASA Science Information Systems Newsletter (SISN) is prepared for the Office of Space Science (OSS), Science Information Systems (SIS) Program through an agreement with the Jet Propulsion Laboratory. The newsletter, which has been an ongoing task for over ten years, is a forum for the space science and applications research community to report research and development activities, outreach activities, and technology transference. SISN offers a venue for articles that are not likely to appear elsewhere and provides the opportunity for information exchange within the science community, as well as a platform for accomplishments by that community. Related articles from other programs and agencies are also published.*

*Questions or comments regarding this newsletter task may be emailed to Sandi Beck at <sandi.beck@jpl.nasa.gov>.*

*Credits: Design and format by Editor, Sandi Beck. Graphics design, animation, and rollovers by Scott Brenneisen, XTREME GRAFX. Also, thanks over the years to Calvin Yee, formerly of Telos Information Systems, Doug Steinwand, formerly of JPL, and the JPL documentation staff.* 

*The Applied Information Systems Research Program (AISRP) maintains an awareness of emerging technologies applicable to space science disciplines, supports applied research in computer and information systems science and technology to enhance NASA Office of Space Science (OSS) programs, stimulates application development where warranted, and provides for the systems analysis and engineering required to transfer new technology into evolving OSS space science programs through NASA Research Announcements.*

# Paradise: A Different Approach to an Information System

*David DeWitt and Jeffrey Naughton, Computer Sciences Department, University of Wisconsin-Madison*

The current Hughes Applied Information Systems design for the Earth Observing System Data and Information System, or EOSDIS, assumes the use of a database system to hold metadata and a hierarchical file system to hold the "data." Paradise, like Project Sequoia [1], is taking a database-centric point of view and assumes that data, as well as metadata, should be stored in a database system. In fact, our view is that data and metadata are both data and that users should be able to store and manipulate both in a single system with a single interface. Many individuals seem to view such an approach as ludicrous. We intend to show that they are mistaken.

There are a number of reasons why we think that the database-centric approach is superior. First, parallel database management system technology [2] such as that marketed by IBM, Tandem, Sybase and ATT/Teradata has proven to provide scalability limited only by the size of one's wallet. For example, the Teradata system currently used by the nationwide, low-cost merchandising chain Wal-Mart for decision support, consists of more than 400 processors and 1000 disk drives (2 terabytes). While 2 terabytes is only a couple of days worth of EOSDIS data, there are no commercially available file systems capable of managing 1000 disk drives.

Another advantage of the database-centric approach is that database systems already automatically deal with two levels of the storage hierarchy (primary and secondary storage). When a query is submitted for execution, the database system optimizes it to minimize execution time by selecting an execution plan that minimizes both CPU usage and the movement of data pages between disk and primary memory. Extending the optimizer and execution algorithms to handle a three-level storage hierarchy is straightforward.

As a concrete EOSDIS-specific example, consider a scientist who wants to process a year's worth of Advanced Very High Resolution Radiometer (AVHRR) images corresponding to a particular region (described by a polygon). With a nonintegrated approach, the scientist will first query the database system for the names of the files containing the images of interest. Then a request will be submitted to the hierarchical storage system to move the appropriate files to disk from tertiary storage. Finally, the scientist can execute the program to process the images. The key point is that each AVHRR image (file) gets transferred in its entirety from tertiary to secondary storage by the hierarchical storage manager.

Contrast this with a database-centric approach with integrated support for tertiary storage and AVHRR images*. Because the scientist's request specifies retrieval of only a subset of each AVHRR image (the portion clipped by the polygon of interest), the database system will move only a subset of each AVHRR image from tertiary storage to secondary storage and/or primary memory. Depending on the relative size of the area of interest and the size of the AVHRR image, the resulting reduction in I/O time can be significant. Because most EOSDIS data sets will reside on tertiary storage, we assert that such savings may prove to be crucial to the success of the EOSDIS project.

An open question with the database-centric approach is how best to integrate the scientist's program with the database system. The approach taken by Project Sequoia is to wrap the program as a user-defined function that gets invoked by the database system as part of the process of executing a query. A less aggressive approach would be to export the results of a query as one or more hierarchical data format (HDF) files that the scientist's program can then manipulate. Another solution would be for the database system to provide an HDF-compatible, call-level interface.

## Paradise overview

The Paradise project was begun in early 1993 in order to demonstrate the viability of a database-centric approach to EOSDIS. The approach being pursued is to apply the object-oriented and parallel database technology developed as part of the EXODUS [3], Gamma [4], and SHORE [5] projects to the task of prototyping a parallel database system capable of managing extremely large, multiterabyte data sets. A client-server version of Paradise is now operational and the development of a parallel version of the system is about to begin.

## Data model and query language

Paradise provides an object-relational data model. Three type constructors are provided: extent, tuple and reference. An extent consists of a set of objects of the same type. A Paradise database consists of one or more such extents. Objects themselves are defined using the tuple-type constructor. A tuple consists of one or more attributes and is like a C++ class. Each attribute can be an instance of either a standard base type (i.e. integer, float, string), one of the predefined geographic information system-specific abstract data types (ADTs) including polygon, polyline, and raster, or a typed reference to another object. The ADTs, their functions and their operators (methods) are defined and coded in C++. The database in Figure 1 illustrates the use of the Paradise data model.

```
Instrument
   (name String, type Integer, manual Text);
CloudCover
   (cloudDensity Raster, measuringDevice ref
   Instrument, date Date);
Rivers
   (name String, shape Polyline,
   flood_plain  Polygon, water_level Integer,
   levee_status Integer);
Cities
   (boundary Polygon,  name String,
   population Integer)
```

Figure 1. Sample Paradise schema

As a query language, Paradise provides an extended version of SQL. To SQL we have added the ability to invoke methods on ADTs, a set of spatial operators, and the ability to follow inter-object references using the standard nested dot notation (i.e. a.b.c).

As an example, consider the query in Figure 2 against the database shown in Figure 1 for finding the current cloud cover over all “large” cities, for which a “flash flood” warning should be issued as shown in Figure 2.

```
Select name, cloudDensity.clip (boundary)
   from Cities, CloudCover
where boundary.area() > 900 and
   date = “9/15/94”
and cloudDensity.clip (boundary).average() > 10
```

Figure 2. Example Paradise query

Here area() is a function that is defined on the polygon ADT, average is a function defined on the raster ADT, and clip is a function on the raster ADT that takes a polygon as its argument. The query selects all cities that have an area greater than 900 sq. miles and “joins” it with the CloudCover tuple that was scanned on “9/15/94.” Further, only those “join” result tuples that have an average cloudDensity greater than 10 sq. inches are produced as result tuples. The result tuples have two attributes: one is the city name and the other is the raster image corresponding to the cloud cover over the city.

## System architecture

The current version of Paradise employs conventional client-server architecture. The Paradise front-end provides a Graphical User Interface that supports querying, browsing and updating of Paradise objects through either its graphical or textual interfaces. The graphical front-end is implemented using Tk [6]. The Paradise server is implemented as a SHORE Value Added Server directly on top of the SHORE Storage Manager. To the basic SHORE server, Paradise adds a catalog manager, an extent manager, a tuple manager, a query optimizer and execution engine, and support for point, polyline, polygon and raster ADTs. In addition, the SHORE server was extended to include R*-trees [7] as a spatial access method (in addition to the existing B-tree mechanism already provided by SHORE).

To facilitate the transparent, but efficient handling of large collections of large raster images, Paradise incorporates several performance optimizations. First, as a raster image is loaded (see Figure 3), it is decomposed into regular rectangular-shaped regions called tiles. The data in each tile are compressed using the basic LZW compression algorithm and then are stored as separate SHORE objects. A map table (one per raster image) is used for maintaining the correspondence between the tile objects and the region of the raster image corresponding to that tile object. Decomposition of the raster image into tiles allows Paradise to fetch (from secondary or tertiary storage) only those tiles that are required to execute an operation, e.g., when a raster image is clipped by a polygonas in the query in Figure 2.

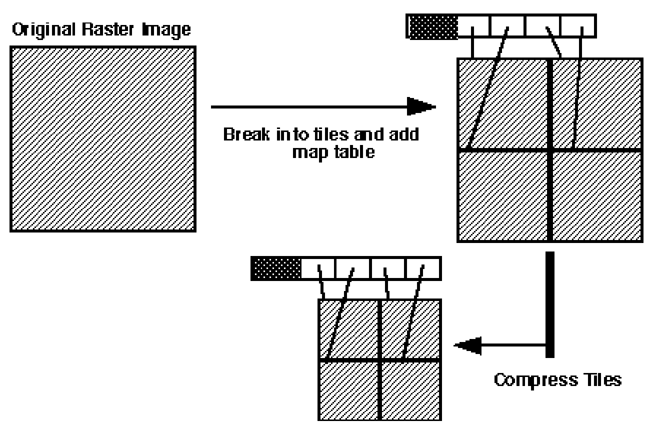



Figure 3. Loading a raster image

Figure 4 shows how Paradise stores the objects of the CloudCover extent from Figure 1. Physically each object consists of three values: a date, the object identifier of the instrument used to take this measurement, and a raster header for the cloudDensity attribute. The objects containing the raster images for the CloudCover extent are stored as objects in a separate SHORE file.

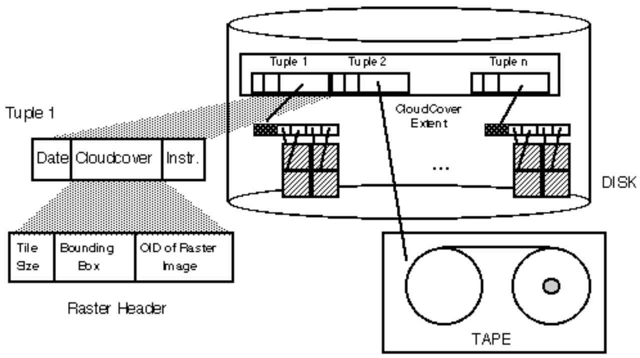



Figure 4. The CloudCover extent

An advantage of this approach is that the objects containing the actual raster images can transparently migrate between secondary and tertiary storage. In addition, by storing the raster images as large objects in a separate SHORE file, the tuples in the primary extent remain physically clustered with one another, significantly improving the performance of a sequential scan over the extent. Finally, even for queries involving the raster attribute, the raster images need not always be brought into memory. For example, consider a clip operation between a polygon and a raster attribute. To determine whether an object satisfies the predicate, only the bounding-box information stored in the raster header part of the tuple needs to be checked. Even if the tuple does satisfy the clip predicate the raster images are fetched "lazily," only when the image actually needs to be manipulated or displayed.

## Status and future directions

The client-server version of Paradise is now operational and release is planned for November 1994. Work on Paradise continues on several fronts. A digital linear tape robot has been acquired and support for it is being integrated into SHORE and Paradise. Second, alternative strategies for supporting HDF data sets are being examined. The initial approach will be to provide import and export mechanisms. Later it is intended that a compatibility layer will be provided so that application programs can make HDF calls directly against Paradise.

The key focus of the next phase of the project will be to implement a parallel version of Paradise. The target architecture is what the database community refers to as "shared nothing" [8] (see Figure 5). In this approach, nodes composed of one or two processors, a small number of disk drives, and perhaps even a tertiary storage device (e.g. a tape carousel), are interconnected via a high-speed interconnection network. Assuming an interconnect whose aggregate bandwidth scales as additional nodes are attached, such an architecture scales indefinitely with each additional processor adding both CPU and I/O capacity. A key advantage of this design is that, except for the interconnection network, the system is composed of "inexpensive" components (processors, memory, disks and tertiary storage devices). The target platform will be a cluster of 40 Sparc20 workstations connected via asynchronous transfer mode.

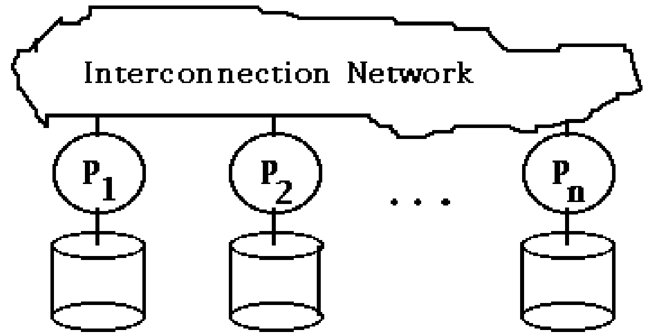



Figure 5. Shared-nothing multiprocessor

The shared-nothing approach, which was pioneered by Gamma and Teradata [9] has been widely adopted by commercial database vendors including ATT, IBM, Tandem and Sybase. It is in sharp contrast to the approach currently planned by Hughes Applied Information Systems for EOSDIS. This design (see Figure 6) involves a set of network-attached secondary and tertiary storage devices connected by a network to a set of processors that runs the reprocessing algorithms. This design (known as shared-disk ) has a number of shortcomings. First, the mass storage components are expensive as they must include a network interface. Second, in order for data to be processed it must be moved across the interconnection network to the processors. Thus, the aggregate bandwidth of interconnection network must be greater than the aggregate I/O and processor-to-processor traffic. Contrast this to the shared-nothing approach in Figure 5 in which reprocessing and database operations are applied in parallel to the data without moving the data through the interconnection network.

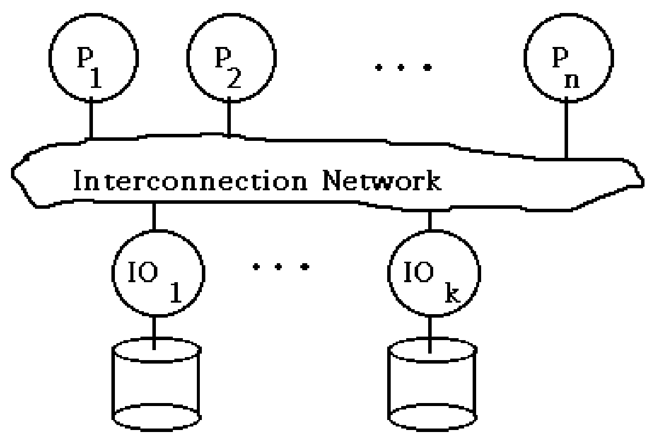



Figure 6. Planned EOSDIS configuration

The Paradise project advocates a database-centric approach to EOSDIS with all data being stored in the database system, not just the metadata. Currently a client-server version offering an extended version of SQL is operational. Benchmark results clearly demonstrate that storing large raster satellite images in a database system is not only feasible but efficient. Future activities include integrating support for tertiary storage, HDF file formats and scalable parallelism.

Learn more about the Paradise project at
<http: //www.cs.wisc.edu/paradise>.

## References


1. Stonebraker, M. and J. Dozier, "SEQUOIA 2000: Large Capacity Object Servers to Support Global Change Research," SEQUOIA 2000 Technical Report No 1, U.C. Berkeley, March 1992.
2. DeWitt, D. and J. Gray, "Parallel Database Systems: The Future of Database Processing or a Passing Fad?," Communications of the ACM, June 1992.
3. Carey, M., et. al., "The EXODUS Extensible DBMS Project: An Overview," in Readings in Object-Oriented Databases, S. Zdonik and D. Maier, eds., Morgan-Kaufman Publ. Co., 1989.
4. DeWitt, D., S. Ghandeharizadeh, D. Schneider, H. Hsiao, A. Bricker, R. Rasmussen, "The GAMMA Database Machine Project," IEEE Transactions on Knowledge and Data Engineering, Vol. 2, No. 1, March 1990.
5. Carey, M., D. DeWitt, J. Naughton, M. Solomon, et. al., "Shoring Up Persistent Applications," Proceedings of the 1994 SIGMOD Conference, May 1994.
6. Ousterhout, J., "An X11 Toolkit based on the Tcl Language," Proceedings of the 1991 Winter USENIX Conference, 1991.
7. Beckmann, N., et. al., "The R*-tree: An Efficient and Robust Access Method for Points and Rectangles," Proceedings of the 1990 ACM-SIGMOD Conference on Management of Data, June 1990.
8. Stonebraker, M., "The Case for Shared Nothing," Database Engineering, Vol. 9, No. 1, 1986.
9. Teradata, DBC/1012 Database Computer System Manual Release 2.0, Document No. C10-0001-02, Teradata Corp., November 1985.
10. DeWitt, D., N. Kabra, J. Luo, J. Patel, and Jie-Bing Yu, "Client Server Paradise," Proceedings of the 1994 VLDB Conference, Chile, September 1994.
11. DeWitt, D., J. Luo, J. Patel, and Jie-Bing Yu, "Paradise - A Parallel Geographic Information System," Proceedings of the ACM Workshop on Advances in Geographic Information Systems, November 1993.
12. Stonebraker, M., J. Frew, K. Gardels, and J. Meredith, "The SEQUOIA 2000 Storage Benchmark," Proceedings of the 1993 SIGMOD conference, Washington, D.C. May 1993. ■


# *Communicating with "ELVIS"*


***Elaine Hansen and Dan Rodier, Colorado Space Grant College, University of Colorado, Boulder and Marjorie Klemp, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder***


The role of visualization in space science is expanding, encompassing exploratory data evaluation and emerging as a valuable tool in interdisciplinary communication. Visualization technologies permit scientists to communicate the informational content of large, complex data sets in a simple, intuitive format readily understood by both scientists and nonscientists in a range of disciplines.

The ability to communicate the essence of a scientific data set through visualization has additional applications in education where the interpretation of the data needs to be conveyed from instructor to student. This is especially true in undergraduate and interdisciplinary education where, for example, a scientist may wish to present global climate change information to precollege students, political science students, computer science students, or journalism students. The Experimenter's Laboratory for Visualized Interactive Science, or "ELVIS," is an interactive scientific visualization tool capable of promoting such interdisciplinary communication, education and scientific exploration.

## ELVIS overview

ELVIS is an interactive visualization environment that enables scientists, students and educators to visualize and analyze large, complex and diverse sets of scientific data. It accomplishes this by presenting the data sets as 2-D, 3-D, color, stereo and graphic images with movable and multiple light sources combined with displays of solid-surface, contours, wire-frame and transparency. By simultaneously rendering diverse data sets acquired from multiple sources, formats and resolutions and by interacting with the data through an intuitive, direct-manipulation interface, ELVIS provides an interactive and responsive environment for exploratory data analysis.

ELVIS is an integrated set of software tools, developed for use on a range of popular and affordable computer workstations, and currently hosted on Sun and Silicon Graphics workstations. These integrated tools include a Graphical User Interface based on Goddard Space Flight Center's Transportable Applications Environment (TAE Plus). The internal architecture is based on a reusable C++ object library that includes objects for 2-D and 3-D graphics, a data object, a geometric object, a light object, and color objects. The 3-D rendering package is an extension of the popular National Center for Atmospheric Research (NCAR) Polypaint package and the data access software is based on concepts from the Network Common Data Format (NetCDF), an access library developed by the National Space Science Data Center.

ELVIS is designed to support the needs of scientists, students, and educators from a range of Earth and space science disciplines. Throughout the program, ELVIS prototypes have been evaluated by representatives of the space science community and the design refined to meet the evolving recommendations of these users.

ELVIS enables you to work on scientific or educational problems (and not on computer science details) by employing an intuitive and responsive user interface. It provides you with the flexibility to present specialized displays while supporting common capabilities with simple instructions.

## Graphical User Interface

ELVIS' Graphical User Interface (GUI) is simple to access, understand and operate. The GUI is key to providing efficient data exploration and communication technology to the scientific and educational communities. The GUI in ELVIS supports these user needs by promoting functionality and maintaining simplicity. ELVIS' pulldown menus are designed to be accessible while minimizing interference with the visualization windows (Figure 1). The pulldown menus each have several pop-up submenus that permit more advanced data and graphical manipulations. The features of the ELVIS GUI are included in a set of editors and tutorials.

The Color Editor allows you to intuitively choose colors for coding data. The colors are identified by sight rather than by number as is common in many visualization packages. The distinction between true color and indexed color hardware is hidden. The direct manipulation color editor allows you to visually select a single color or build a complex color ramp without knowledge of the hardware or the underlying software.

The View Editor, manipulated in 3-D within a fixed coordinate system, enables the perspective of the "user's eye" to be adjusted by moving the eye in one plane at a time or in all

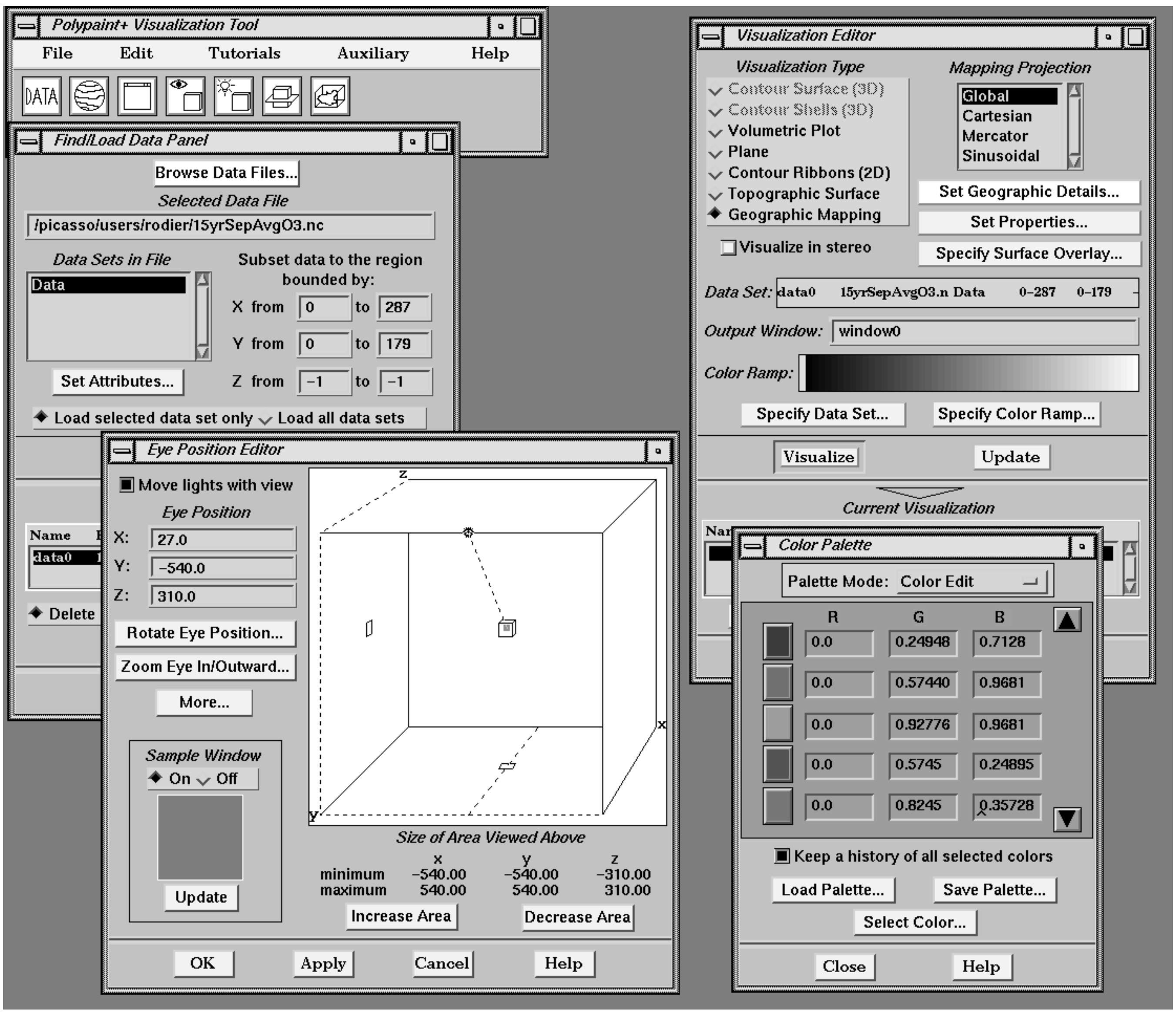



Figure 1. ELVIS' graphical user interface is key to effectively providing graphical data exploration and communication technology to the scientific community

planes simultaneously. Before rendering, you can check the orientation of the 3-D object using a low-resolution panel. The view angle can also be changed by directly manipulating a diagram representing the actual visualization.

The Light Editor allows you to add and delete light sources and shadows with the ability to change their color, properties and location.

The Visualization Editor displays a selected data set using default attributes. Displays of the default attributes may then be modified to tailor the visualization to your own needs. The meta-data are also stored in the data object allowing the visualization editor to make intelligent decisions regarding the defaults.

Tutorials that provide new users with a demonstration on how to utilize ELVIS are also available as part of the GUI. Context-sensitive help is available for any menu window by first selecting the help button and then clicking on the item or object for which information is desired. By integrating comprehensive help and tutorial information into ELVIS, the time and effort required to learn the package is reduced.

## Data visualization techniques

ELVIS, with its Polypaint+ rendering package developed by NCAR, provides procedures for displaying complex structures in 3-D data fields using color-shaded surfaces and provides the ability to control lighting, viewing and shading. Data volumes can be sliced and the cross sections displayed using 2-D graphics options. ELVIS provides a number of visualization methods including:

- 3-D topographic surfaces where data fields and topographic surfaces may have different resolutions
- 3-D volumetric or density visualizations
- 3-D isosurface and transparent isosurface shells
- 2-D graphics that can be interacted with via the mouse. The value and location of the data are displayed when a graphic object (contour line, map outline, vector, or raster image) is selected.
- 2-D contour plots featuring contour lines and color-fill contour regions as display options
- 2-D vector plots where you can visualize vectors based on magnitude and direction. It differs from straight vectors because an interpolation scheme is used to calculate the magnitude and direction at small time intervals, thus showing any small curvature that the vector may have.
- 2-D raster images (see Figure 2)
- 2-D map outlines using the World Data Bank II. Map features can be added or deleted interactively to provide more or less detail (see Figure 2).
- Projection and 2-D window capability allow correct placement of data in a 2-D window according to either the meta-data or user-specified world coordinates. Data can be projected in Cartesian, Mercator or Lambertian coordinates.

The Meteor-3 Total Ozone Mapping Spectrometer data used in this plot was obtained by anonymous ftp from Goddard Space Flight Center.

## Features for the scientific user

The value of ELVIS to the scientific community is based on its simplicity, durability, large data capacity, and its easily understood function menus. Beyond its base structure, ELVIS incorporates several features that are particularly useful to scientists.

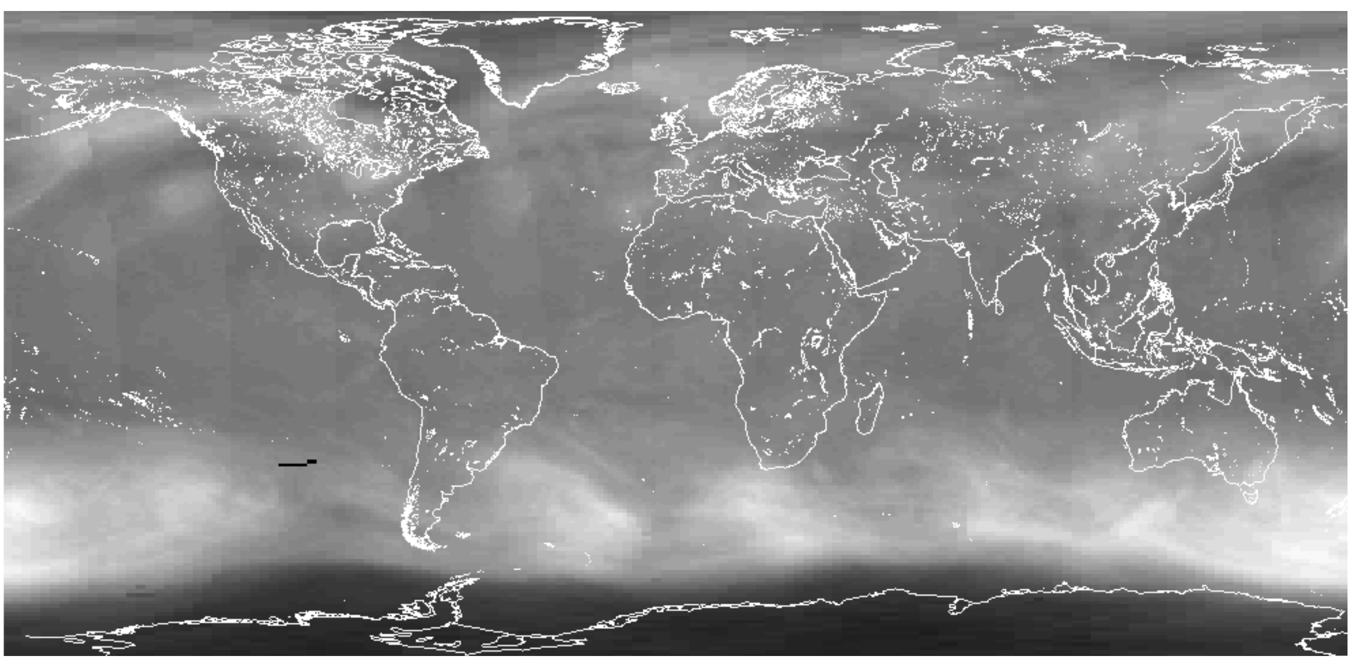


Figure 2. A 2-D raster plot of global ozone illustrating Antarctic ozone depletion. The World Data Bank II map features are overlaid for geographic perspective

- True color surface shading allows you to visually identify small anomalies in the data. The use of true color surface shading permits visual recognition of features not discernible through traditional indexed shading or simple numerical evaluation of the data.
- The ability to insert a discrete color into a color ramp using the color editor menu permits you to highlight features in the data. It complements the contour mapping features. For example, this feature is being employed to insert narrow bands of bright red into a gray-scale ramp in order to visually isolate and roughly quantify small fluctuations in global total ozone measurements.
- Visualization of large data sets provides you with an information-rich assessment of the data in a fraction of the time necessary to prepare and perform numerical evaluations and comparisons. With visualization, the interpretation is simple and rapid, with resultant decreases in the time necessary to interpret more detailed numerical evaluations.
- Manipulation of the data visualizations created in ELVIS is convenient and straightforward.
- With the selection of appropriate surface overlays and shading, the scientific information contained in a data set may be intuitively understood by nonscientists. For example, by displaying global ozone data overlaid on a map of the Earth's surface, the resulting visualization is that of "ozone clouds" over the globe. From this type of visualization, an understanding of how ozone varies from location to location and with the seasons is readily available to all. These features make ELVIS a valuable communication tool for education.

## Hardware and data formats supported

ELVIS has been tested on the Silicon Graphics and Sun 4 workstations. Data conversion from a variety of binary formats to NetCDF, so they may be read and visualized, is achieved via a window menu integrated into ELVIS.

## Visualization applications

The ELVIS tool has been used to visualize planetary data (Figure 3), meteorological data (Figure 4), and atmospheric constituents (Figure 2) from the perspectives of scientists, new users (not programmers), students and educators. The visualizations of Earth and space science data are being used at the Colorado Space Grant College (Figure 5) to educate students and to encourage high school students to pursue their interests in space-based research.

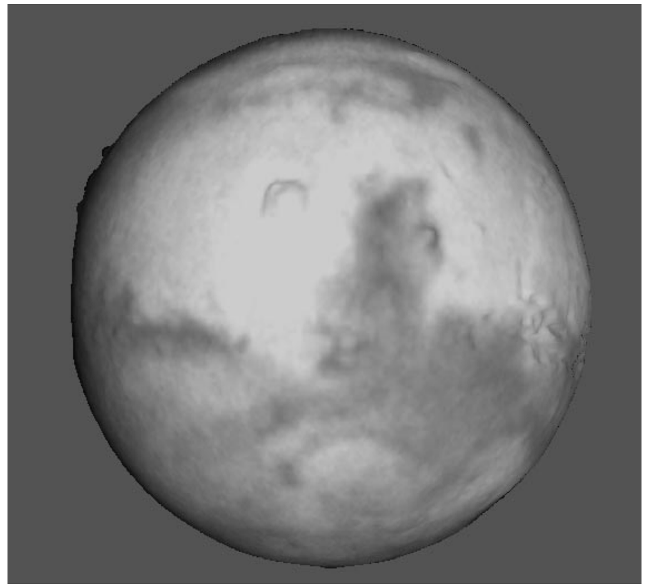


Figure 3. A 3D visualization of Mars elevation data overlaid with red filter albedo data from the Hubble Space Telescope. The surface features are exaggerated by a factor of 50

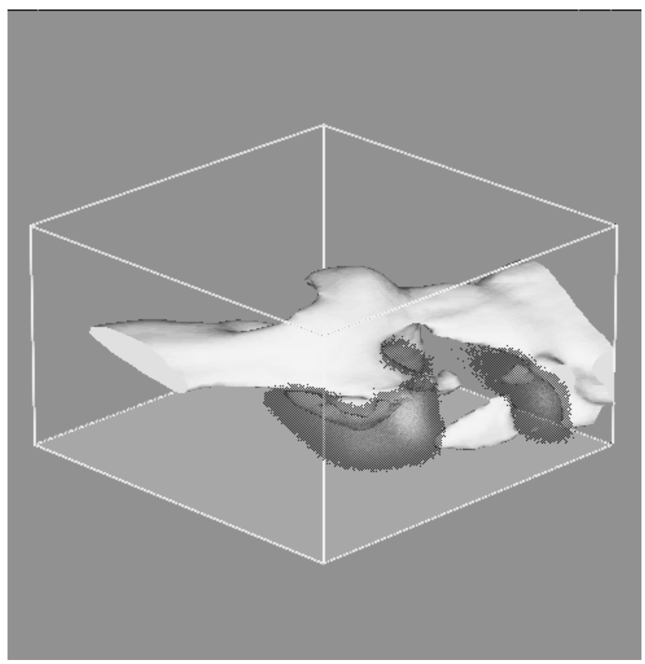


Figure 4. A3D isosurface of a clouid with a rain field rendered transparently. The baseplane and bounding box provide the relative orientation of the cloud model data


Figure 5. Visualizatins of Earth and space science data are being used at the University of Colorado Space Grant College to educate students and to encourage high school students to pursue their interests in space science and technology fields.

The use of ELVIS as an educational communication facilitator has been promising in its early applications. Students are able to grasp more complex scientific phenomena with less effort and time. We plan to use visualizations from ELVIS in portions of the University of Colorado's "Introduction to Space Experimentation" course in the spring of 1995 to provide engineering undergraduates with an overview of Earth science as observed from space. It is anticipated that interdisciplinary applications such as this will benefit from the enhanced communication afforded by scientific visualization.

Learn more about ELVIS at <http://polypaint.colorado.edu:4444/home.html>. This page contains many sample graphics. It also describes the software and workstation requirements. ELVIS is available at no cost to those who sign a license agreement.

## Acknowledgments

This research was inspired by Jeff Star of the University of California at Santa Barbara who helped develop the initial ELVIS concept and who served as a representative of the educational and Earth science community. His contributions, vigor and friendship are remembered.

The authors also gratefully acknowledge the participation of a core development team made up of talented and dedicated scientists, engineers, and students from the University of Colorado's Space Grant College (Anthony Colaprete, Allison Kipple, Mike Porkert, Jennifer Ray, and Kevin Stephens) and Laboratory for Atmospheric and Space Physics (Eric Hillis and Ed Loehr), from the National Center for Atmospheric Research (Bill Boyd and Scott Davis), from Goddard Space Flight Center, and from the University of California at Santa Barbara. This core team was assisted by a group of talented and supportive scientists who helped evaluate the prototypes and guide the design, made up of Joe Klemp, Steve Lee, O.R. White, Gary Rottman, Gary Heckman and others.

The work was supported by a contract from the Information Systems Office of NASA's Office of Space Science, and by students earning research and design credit at the University of Colorado. ■

***The Applied Information Systems Research Program (AISRP) maintains an awareness of emerging technologies applicable to space science disciplines, supports applied research in computer and information systems science and technology to enhance NASA Office of Space Science (OSS) programs, stimulates application development where warranted, and provides for the systems analysis and engineering required to transfer new technology into evolving OSS space science programs through NASA Research Announcements.***

# AstroNet: A ToolSet for Simultaneous, Multisite, Remote Observations of Astronomical Objects

***Sherri Godlin and Supriya Chakrabarti, Dept. of Astronomy, Boston University***

With increasing limits on observing time and rising costs for observing projects, automated, remotely controlled telescopes can greatly assist modern astronomy by performing routine, survey observations as well as other types of research. Some research topics, such as the tracking and monitoring of minor planets (asteroids, comets, etc.), usually require multisite observations for position and orbit monitoring. Other topics require many observations taken over a period of time in a number of different wavelengths. Also desirable is the ability to make observations as soon as "unusual" astronomical events are first detected.

A good example of research that would benefit from wide wavelength coverage, short notice observation capabilities, and long-term observing support is supernovae-related research. As supernovae occur unexpectedly, being able to coordinate observations as soon as possible after they occur is vital. Usually, observing in as many wavelengths as possible and using different instruments soon after the first signs of the supernova are detected, are difficult. National observatories are generally not available for these types of observations because their time is in such high demand and granted to individual astronomers or institutions for observing runs. For this reason, monitoring projects and observing run interruptions are usually not possible, or at least not common.

## Network of observatories

AstroNet—an interactive astronomy tool that will provide an international network of observatories and space-based instruments—is presently under development. When completed (tentativevely scheduled for the end of the year), network members will be able to use fully automated and robotic telescopes as well as make requests to other members for simultaneous, remote observations. Institutions currently involved in this project are Boston University and the University of California, Berkeley. Instrument status and site and weather conditions as well as data will be sent over the Internet to the observer in real time or near-real time, depending on the type and size of data being taken.

The software, named Tool-Set, is a networking platform that allows a UNIX analysis machine to interact with a PC running telescope functions. It is written in the tool command language (tcl) and will be available at no cost in the public domain. It is planned that network members will be able to watch observations being run at other facilities in real time. In this way, astronomers and students of astronomy can be passively involved in astronomical research, even if they won't have control over the telescope or instruments being used. This ability for anyone with Tool-Set to "browse" through research being done on any particular night is an important educational and collaborative tool. However, the ability to do simultaneous multisite observations of individual objects and star fields is the primary goal of AstroNet. By doing so, we are building a network environment to support coordinated, collaborative research, as well as make possible multiple instrument observing campaigns by a group of investigators without leaving their home institutions. All software developed for AstroNet runs on UNIX workstations; a PC version is being developed.

The initial constituency of the network is expected to be college- and university-associated astronomers and observatories and amateur astronomers. With the AstroNet network, member astronomers could request support observations as soon as something "interesting" is detected. Private observatories, while normally not equipped with the research-grade telescopes that national and large university observatories have, do have complete control over what is observed, and could readily answer an observing request or provide additional support observations after the initial detection.

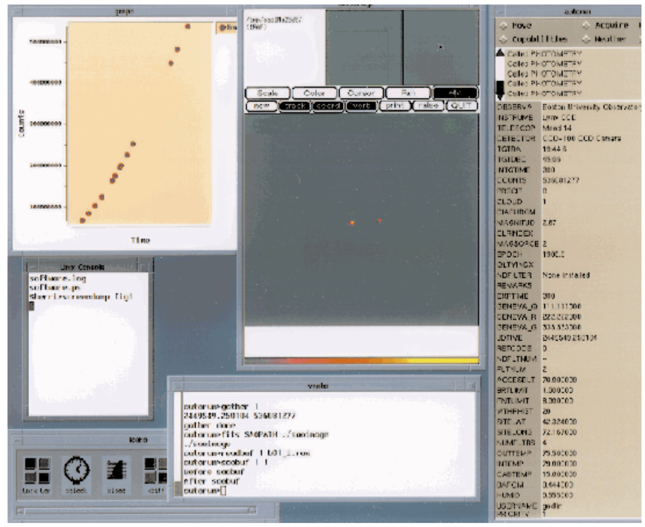
Any assistance rendered by members of the network would be voluntary. In cases where the telescope and observatory have the capability, an astronomer at a remote location could then operate a network member's instruments; or the local operator could perform the observation in cases where full automation is not possible. This could prove especially useful for operation of telescope domes (e.g. the telescope and camera can be controlled by computer, but the telescope dome often must be opened and/or moved manually). Local control is also appropriate for checking on weather and climate conditions. Observatories with the computer capability for watching an observation at an automated observatory could remain online. Thus, their ability to receive other requests and status information about other sites and research would remain intact.

Telescope "owners" will have the final word on how their telescopes will be used. AstroNet will interrupt ongoing observations by member observatories for target-of-opportunity observations and then return the observatory to continue its originally scheduled observation. The fully automated observatories that are controlled by the consortium, that is, they do not belong to a private group or university but are operated and controlled solely by the AstroNet project, will be available for research by submitting observing requests. Each request will be assigned a 'priority' value and schedule. Presently, AstroNet includes rudimentary observation scheduling. However, the project is investigating the incorporation of AI-based scheduling under development at Ames Research Center by Mark Drummond and collaborators.

Observing requests by network members to automated telescopes will be made over the Internet and should consist of object information, such as: source name and location (right ascension and declination); telescope information, (telescope(s) and instrument(s) required for the observation); observational information (number and length of exposures, filters used, and repetitions); and user information (user ID, e-mail address and security passwords). This information is necessary for photometry and imaging. Once the spectroscopy and interferometry platforms are added to the system, the parameter files will be updated and fashioned for the type of observation to be done. This information can be sent either in batch mode or in real time. In both cases, the observer can be interactive with the system, directly in the latter case, and by interrupting a batch observation in the former.

## Network environment

The programs that carry the information between the observer's computer to the telescope and its computer are called autorun.c (the telescope supervisor program) and control.c (the multi-telescope control program). Both have been completed and are being tested for their use on a Sun workstation. Each observer/telescope link provides a graphical user interface (GUI) panel that displays the telescope information, parameter values, weather and site conditions, and a scrollbar window where text messages from the telescope are displayed (see figure). To send commands to the telescope selected or to enter telescope parameters during observing sessions, you can either type directly into the telescope graphical user window on the appropriate variable line or you can type a command to set the value for a specific parameter in your control window, which is sent to the 'autorun' process for the currently selected telescope. You can also select to observe in batch mode by writing a procedure in tcl and entering the name of the procedure in your control window. Control.c is similar to autorun.c and is used when one observer wishes to control more than one telescope at a time from the same computer. When this option is selected, a GUI is provided for each telescope.



A binary star system is being "observed" in this simulated autorun session of AstroNet.

An example of a simulated autorun session is shown in the following figure. The objects being "observed" are Cygnus A and B, a binary star system. The GUI window is located in the right portion of the figure, titled 'autorun.' In it, the various commands, such as Move, Acquire, Capabilities, and Weather are activated by clicking on the appropriate buttons. Parameters can also be entered by clicking on the appropriate line and typing directly into the window. The middle, scrollbarred section of the window is where commands and messages are displayed. In the middle of the screen the image display window, SAOImage, is shown. SAOImage, developed by the Smithsonian Astrophysical Observatory, is used throughout astronomy and space physics, and all data analysis that are available through SAOImage are available. These include options such as aperture photometry, image arithmetic and image calibration.

Below the SAOImage window is the User Command window, an alternative place to call commands and set parameters. The upper left portion of the figure is the graphic display of photometric data, again of Cygnus A and B, which is updated as more data are taken and plotted against time (Julian Date). This is especially useful for variable objects, such as binary stars and pulsars. All data are stored in Flexible Image Transport System (FITS) format, the standard data format system in astronomy, and can be sent to your current account or to a set ftp or e-mail address. Security and data compression issues are still being addressed.

Another feature available to network members is autowatch.c, which monitors the progress of an observation in real time. A passive user can have several 'autowatch' processes running on their workstation, simultaneously, each monitoring a different telescope. The GUI panel used in ‘autowatch’ is the same as in the ‘autorun’ procedure, except that all controls in the ‘autowatch’ panel are disabled, with the exception of the scrollbar in the window where telescope/instrument text messages are displayed.

### Participation

AstroNet can be a powerful educational tool for both high school and college students, as well as for amateur astronomers. Interested parties that do not have a telescope may still participate in the network by watching observations taking place at other observatories, requesting time at other telescopes, and participating in system testing.

Interest in the AstroNet program has been shown by responses to a electronic bulletin board notice summarizing the work being done and asking for feedback from the professional and amateur astronomical community. Potential network members include: amateur astronomers who mainly want to be able to watch astronomy being done; other amateurs (who have fully computerized telescopes) wish to be full participants in the network; professional astronomers at small colleges and universities who see this project as a way to enhance their research potential and broaden their students’ education; and professional astronomers who would like to use this network to further their own research by gaining support observations and complete data sets.

Other telescope groups have also expressed an interest in AstroNet, such as the North American Small Telescope Cooperative, managed by Jason Cardelli of the University of Wisconsin. Also interested are e-mail groups that concentrate on sharing knowledge about robotic telescopes and interfaces, such as the “Robotic Telescope Interface,” an electronic bulletin board whose home base is Bradford University, UK. Other international interest has come from the Czech Republic, British Columbia, Holland and New Zealand.

All necessary software will be put onto the Internet and will be available by ftp and is in the public domain. This includes tcl and tk and the BLT extensions used by the various programs. However some additional commercially available software and/or hardware may be required to run AstroNet, such as FORTRAN for a Sparcstation, or a modem if you are not on the Internet directly.

### Acknowledgements

Other project collaborators include Garret Jernigan and David Vezie of University of California at Berkeley. For further information contact Sherri Godlin at: 617-353-6363; .

This work is funded by University Space Research Association subcontract #5555-13.

Office. ■

# Upcoming Event: Live From Antarctica

Four live telecasts—including the first ever from the South PoleÑwill be beamed to two interactive classrooms and fed to PBS stations and schools via satellite on December 13 and 15, and January 10 and 19. Supported by the U.S. Antarctic Program and NASA, and using a National Oceanic and Atmospheric Administration satellite (GOES-2) for the South Pole broadcast, the program is a collaboration between Maryland Public Television and Geoff Haines-Stiles Productions, in association with WTTW/Chicago. Students will participate from Maryland; Honolulu, Hawaii; Charlottesville, Virginia; Chicago, Illinois; Weslaco, Texas; and Barrow, Alaska. They will be able to discuss Antarctica’s geology, weather, biology and astronomy with Antarctic scientists.

*Excerpted from NSF press release 94-74.* ■

# Internet Project Extends Networking to Watsonville High School

**Pat Kaspar, Ames Research Center**

Ames Research Center's Kindergarten through grade 12 (K-12) Education Project is spearheading a pioneering effort to bring cutting-edge networking capabilities to a local high school in Watsonville, Calif.

***"Watsonville High School has been one of the leaders in computer-aided design and computer-aided manufacturing on the West Coast," said Mark Leon, project leader for the NASA K-12 Education Project, "but it has had no Internet infrastructure to tie its students to the rest of the world. Our engineers will work with Watsonville High School teachers to develop a prototype CAD/CAM curriculum with an emphasis on aeronautics. We are also working with major aeronautics companies to establish a program to allow students to exchange designs with industry over the Internet. When the curriculum is complete, it will be available throughout the United States on one of the NASA K-12 computer networking servers called Quest located at Ames."***

Ames Research Center's Dora Lopez and Kevin Jones, lead engineers for the project to develop the prototype classroom curriculum, designed the high school's local area network, or LAN. The LAN will be built by a subcontractor and managed by I-NET, the new on-site information and communications support prime contractor at ARC. According to Lopez, the NASA Science Internet will provide the wide area networking connection to Watsonville High School.

***"One of the main goals of the program," said Leon, "is to raise the scholastic expectations of the students in Watsonville. There is also a 'value added' component of this project that will allow students to work with major aeronautics corporations."***

Funds for the LAN and peripheral equipment have been provided through the NASA Headquarters' Information Infrastructure Technology Applications (IITA) program headed by Paul Hunter (Office of Aeronautics), and the National Research and Education Network program. The IITA is a research and development program responsible for developing the technology required for the National Information Infrastructure and is funded by the High-Performance Computing and Communications Office. Network equipment, computers, and software will be loaned by NASA to the high school.

***"Watsonville High School will be the first high school in the nation to have a high-speed T1 line," said Leon. "In the future, this type of arrangement will be commonplace, but very few schools have the resources today."***

Lean more about Quest at <http://quest.arc.nasa.gov>. ■

*Improving Earth Science Education in Maryland —*

# *Federal, State, Local Governments Collaborate in a Teaching Initiative*

***Jarrett Cohen, Hughes STX Corp., High Performance Computing Branch, Goddard Space Flight Center***

Earth science is experiencing hard times in US high schools. "Many schools have . . . dumped Earth science as a viable course; they don't offer it," said Richard Farrar, Jr., a teacher at Northern High School in Accident, Maryland.

This low status reflects a long-held notion of the discipline as a poor cousin of the natural and physical sciences. Heightened awareness of environmental problems and of the need for an interdisciplinary approach to solve them are energizing the field in the research and government communities. Leading the charge is the U.S. Global Change Research Program, which this year is coordinating nearly $2 billion of research and policy development across 18 agencies and departments.

***A growing movement at the national and state levels is aimed at making the same kinds of changes in the education community. "The national standards are promoting Earth [science]," Farrar said. "Maryland's state assessment program has put emphasis on it as well. Schools will be forced to beef up their curricula."***

The Goddard Space Flight Center (GSFC) is leading an effort ??The Maryland Initiative?? to improve Earth science education by getting teachers and students directly involved in the research process. In keeping with the focus of the NASA and GSFC education plans, its centerpiece is a teacher-training program.

Farrar is one of 24 teachers chosen by their school districts to be Earth & Environmental Science Teacher Ambassadors. The goals of their participation in the Maryland Initiative are as follows:

- understand how Earth systems can be studied from space and how data gathered in this manner can be used in the classroom
- identify how to use computers and computer networks
- understand how to access and use available NASA resources
- implement knowledge and skills acquired through the program
- share teaching materials and strategies with other teachers through electronic means, seminars and workshops

While the idea for the program germinated at a GSFC Mission to Planet Earth Conference for educators, the center is just one of several federal and state partners collaborating in this effort. These partners include NASA Headquarters—Information Infrastructure Technology and Applications Program; GSFC—Earth Sciences Directorate, Educational Programs Unitit, High Performance Computing Branch; U.S. Department of Energy; Cecil County (Md.) Public Schools; Maryland State Department of Education; Maryland school systems; and the University of Maryland. The current group of teachers will be involved in the program for two years. GSFC is seeking co-funding to add two groups of 24 teachers and their schools in 1995 and 1996.

## Seminars for learning and sharing

The teachers' training began with a four-week institute this past summer, with two weeks each at GSFC and the University of Maryland at College Park. There were sessions on a variety of topics, principally NASA Earth-observing programs; other Earth-monitoring efforts; computers, CD-ROMs, and networks; and hands-on research activities appropriate for students. The teachers also went on several field trips to learn about the ecology in different parts of the state.

***"[The institute] allowed me to learn specific information I may not have known about otherwise," said Kevin Connelly, teacher at Perryville High School, Perryville, Md. "It was also good to see that the scientists at Goddard didn't have all the answers. I try to explain to my students that science isn't a dead issue. It is changing all the time."***

Ann Sullivan, a second-year teacher at Hammond High School, Columbia, Md., pointed out that it was valuable to meet with more experienced teachers. "I've already used some of the lessons," she said.

The summer sessions were only the beginning, however, as the Maryland Initiative is specifically intended to provide the follow-up lacking in many training efforts. "It's probably the most important part of the program that they're continuing it," Sullivan said.

This support includes eight seminars throughout the school year. They provide time for problem solving, for teachers to continue sharing with each other, and for introducing new computer technology and science concepts. In addition, working Earth scientists from GSFC serve as advisers to the Teacher Ambassadors.

## The tools of research

The Maryland Initiative also empowers the participating teachers by supplying them with Earth-monitoring instruments and a computer system with a full complement of peripherals. The bulk of the schools also are being connected to the Internet (see related story on p. 18).

***"The teachers took equipment back with them," said James Latham, principal investigator of the Maryland Initiative and former director, Division of Instruction, Maryland State Dept. of Education. "They will compare their readings with NASA readings and each other—through email.""***

During the summer, the teachers learned how to measure such phenomena as solar ultraviolet radiation and the ozone layer (see related figure). The instruments make field experiments possible, with the added benefit of having environments from across the state for comparison.

Each school received an Apple Power Macintosh 6100/60AV with a built-in CD-ROM drive. Several software packages were installed, including SoftWindows, which allows the Power Mac to act as a DOS machine. Among the peripherals are a high-quality laser printer, a liquid crystal display device for use with an overhead projector, and a laserdisc player.

Internet access allows the Teacher Ambassadors (see figure)to obtain educational resources and to communicate among themselves and with GSFC advisers and technical staff.

## Classroom impact

This fall the Teacher Ambassadors are beginning to implement ideas developed as a result of their participation thus far.

***"The main thing that I do with my students is a lot of hands-on inquiry," said Connelly, a 15-year veteran. "Rather than just spouting out a lot of facts and information, I like the students to explore and come up with answers on their own."***

Connelly teaches biology, computer programming, and Advanced Placement Computer Science. His biology course has a large unit on environmental science, but he also foresees impact on his computer science classes. For instance, Connelly plans to bring the two disciplines together using the laserdisc as the medium.

***"The computer programming students will program the laserdiscs for use in the biology classes," he said.***

Among the assignments Connelly finds effective are "climatograms," graphs of temperature and precipitation for a given region over a year. The students previously graphed them by hand but will now use the computer.

***"They can spend less time on making the graph and more on learning what it means," Connelly said. The data for climatograms and other projects will be obtained from the Internet. "Instead of taking data from the textbooks or making it up, we'll have the latest, state-of-the-art data," he said.***

***Sullivan also pointed to the benefit of students "having up-to-date information at their fingertips. "The big thing is to use the Internet for student research," she said.***

Teaching Earth science and biology students at a variety of skill levels, Sullivan believes in creating a positive learning experience. She first plans on doing a transpiration experiment with her Earth science class. But Sullivan will adapt her approach as needed.

***"If it is not working in the middle of the year, we'll modify it," she said.***

Sullivan's teaching often takes an interdisciplinary approach. Last year, her students created a rain forest in the classroom. The project encompassed science, art, history, math, and English, with the students doing haiku and oral histories. This year, she plans on including cross-cultural education in her classes by using the Internet to get involved with foreign countries.

***Farrar, who came into teaching after a career in business and research, sees the Maryland Initiative as reinforcing his own ideas about teaching. "I got involved because it held out the promise of being with people who shared my desire for real-world, real-time data to use in the classroom," he said.***

His course, "Matter and Forces in the Universe: And the Mission to Planet Earth," has the same foundation as NASA, primarily focusing on observation and the data collected from it. Farrar's students become second-graders again and look at patterns and breaks in patterns."

One class project involves changing weather satellite images into gray-scale maps in order to forecast the weather. Farrar explained that the students do 18- and 42-hour forecasts, which are 84% and 68% accurate. He hopes the computer will help the students better massage the images to "come up with their own ideas about how the solid Earth and fluid Earth interact."

## Ambassadors to a wider community

***The Teacher Ambassador concept does not stop with the individual classrooms. Each teacher is also to share knowledge with their school and their district as a whole. "The idea is to be an ambassador to other teachers, to the community in general," Farrar said.***

Sullivan and fellow-Ambassador Michael Anikis teach in Howard County, a suburban school district located between Washington, DC, and Baltimore. At the start of the school year they spoke to the district's science teachers about their experiences. Later in the fall, Sullivan plans to have a session on using the Internet for those at her school. The computer in her classroom is also seeing wider use.

***"Since I've gotten the computer, we've ordered programs to make films. The word is getting around," she said.***

***"It is like a life-changing event for a single piece of technology to rear its head," Farrar said of rural Garrett County in Northwest Maryland.***

His school, however, is involved in networking projects with the National Science Foundation and the Bell Atlantic Distance Learning Program. The latter is providing videoconferencing to the district's two high schools as well as Garrett Community College.

Because of their geographic isolation, the county is not yet connected to the Internet. Nevertheless, Farrar brought the middle and high school teachers together to talk about eventual use of the Internet in fields other than science and had a meeting with community college officials about Internet access.

***"If I'm not seen as a lone ranger and this is seen as a real-world thing, I can be more influential in making this technology accessible to the county," Farrar stated. "To the extent that they can see me as connected with something they recognize—NASA—they'll listen to me."***

Connelly teaches in Cecil County, a largely rural district that sits at the head of the Chesapeake Bay. Already leading a course on computer programming for district teachers, Connelly has given and plans on giving several more talks on what he has learned. He is particularly interested in showing how the Internet can be used to obtain weather information in picture form.

***"I hope this room becomes a global classroom," Connelly said. "We can start talking to people from all over the world, sharing ideas, sharing cultures. It will show that there's something outside of Cecil County, Md. That's exciting. The first step is to make [the technology] available. If you can get people excited about the possibilities, then you can work out the details as you go along."*** ■

# The Maryland Networking Challenge

***Jarrett Cohen, Hughes STX Corp., High Performance Computing Branch, Goddard Space Flight Center***

With an odd-shaped state split by the Chesapeake Bay and few large population centers, a great challenge for the Maryland Initiative was building a network to connect the schools to the Internet.

***"It turns out that there were really two support problems," explained Javad Boroumand, principal systems engineer, Hughes STX Corp./Computer Networks Branch, GSFC. "One was finding a place to get an Internet account. The second was solving the long-distance problem."***

GSFC had decided on the point-to-point protocol, or PPP, as the most appropriate Internet access method. While employing dial-up and telephone lines, PPP is more advanced than similar approaches in that it allows caller sites to become nodes on the Internet.

***Boroumand and collaborators first explored several intra-NASA alternatives for PPP service but rejected them due to excessive cost or insufficient capacity. "The next thing was for us to investigate the viability and usefulness of the commercial Internet access providers," Boroumand said. GSFC evaluated the three major providers in the state and, after a testing period during the summer training program, selected Greenbelt, Md.-based Digital Express Group, Inc. (DIGEX).***

DIGEX was chosen for quality of service and their willingness to cover more schools in the state, the latter of which resulted in a solution to the long-distance problem as well.

The company's Maryland customers obtain PPP service by dialing into Points of Presence (POPs) that are close enough to allow access at the price of a local telephone call. However, DIGEX just had POPs in the Baltimore-Washington area, in which only 10 of the schools are located. The other 14 would have to make long-distance calls for network access, the essence of the general distance problem.

Discussions began with Bell Atlantic and AT&T about a contract using special lines to bring the schools closer to the DIGEX POPs. GSFC staff were concerned about the legality of this approach. Boroumand explained that while the companies did not say it was specifically illegal, they implied that tariff regulations might be interpreted in an unfavorable way in the future, particularly for crossing the Bay.

***"Meanwhile, we thought the best way to eliminate the legal question for us as well as to help further expand this commercial service," Boroumand said, "was to take the money . . . and give it to DIGEX to also solve our long-distance problem on the telecommunications side."***

President Doug Humphrey started DIGEX in his basement with four dial-up lines in 1991. There are now 400 lines in Baltimore-Washington, New York City, New Jersey, and parts of Pennsylvania. At $2 million in revenues last year, DIGEX is a small company, and Humphrey said that the Maryland Initiative "is helping us expand to areas where there is no service."

The solution includes establishing several additional POPs west of the Chesapeake Bay; these reach four of the remaining 14 schools. Connecting the eight schools across the Bay is more difficult, both technically and financially. While an Eastern peninsula POP was not possible, DIGEX agreed to install a dedicated line to reach most of those schools with local access. Three of the 24 schools, two in the far west and one in the far southeast, are not yet networked but will be as larger markets warrant additional POPs.

***"It's an engineering challenge as well as a commercial opportunity," Humphrey said. "Once in there, we can expand knowledge to other facilities and provide access to them as well."***

This scheme is also more cost-effective and will allow schools to afford the service on their own after the end of NASA's three-year commitment. Boroumand said that having separate Internet access and telecommunications contracts would have cost $24,000 per year. DIGEX has agreed to provide both services for only $11,000 per year.

***"There is a reduced government cost in providing for [access]," Boroumand said. "We either would have had to reduce service or pay for everything. With this service the schools will be able to afford it."*** ■

# NASA Master Directory and Approaches to Information Searching

***Jim Thieman, National Space Science Data Center, Goddard Space Flight Center***

The National Space Science Data Center (NSSDC) at Goddard Space Flight Center has for many years operated and continues to operate a NASA Master Directory (NMD). This service enables the research and general community to quickly find information about and the location of data of interest, especially in space science. Recently, network tools such as the World Wide Web and Gopher have provided capabilities similar to the NMD for the finding of data and information. Is the NMD something that can now be replaced by these tools? This article will discuss that question and the various approaches to obtaining directory information.

The NMD directory service is available online and is accessible through several types of interfaces. The directory interfaces have evolved as the technology for creating them has progressed. A Web interface has been developed for the Global Change Master Directory (GCMD) by the GCMD staff and has been modified by the NMD staff so it can be integrated into the many other data and information services that the NSSDC has to offer. This interface offers a simple yet powerful search capability. Through this and other interfaces, the NMD provides information about data not only at NSSDC, but throughout the world. For some of the data sets there are systems in other locations that provide more detailed information about the data. The older interfaces provide automated connections, called links, to these other systems so you can find information and data quickly. The Web hyperlink capability will be used to provide similar service for Web directory users.

Although network tools such as the Web and Gopher are simple, powerful, and access a wealth of information, they still have shortcomings that can lead to ineffective searches for data and information. There are advantages and disadvantages to each of several approaches to finding directory information. The approaches to be examined are World Wide Web search methods, centralized directory searches through standardized information, text retrieval searches through general directory information, and searches through widely distributed directory information.

## Web search methods

The popularity of the Web cannot be denied. The figure shows that Web usage on NSFnet has increased by a factor of six for the first nine months of 1994 and it is overtaking many popular methods of transferring bits through the networks. The ability to use embedded hyperlinks to hop from one information source to another at a different location makes it easy to reach widely separated sources of information. What is more difficult, however, is finding exactly the right piece of information. A number of "spider" services have been created that navigate through the Web automatically and gather information from the titles and text found on the Web pages. Often this textual information is indexed or organized so that you can quickly find where a few keywords of interest have been used. Many services use the Wide Area Information Servers (WAIS) text indexing capability, for example, the Webcrawler service offered by Brian Pinkerton at the University of Washington.

If you have some idea of particular sources for the information you are seeking you can often reach your desired destination with well-chosen keywords. However, a search for all sources of information relevant to a particular topic will often be difficult due to: the lack of standardization of terms describing the topic, the mixing of the relevant information with other information irrelevant to the search, the multiplicity of pages that must often be navigated to reach exactly what you is being searched, and the inability of major institutions to describe in detail all available information.

For example, if you are interested in radio astronomy data from the planet Jupiter, entering the keywords “radio,” “astronomy,” and “Jupiter” in the Webcrawler mentioned above yields some useful pages compiling lots of information and hyperlinks in astronomy. You must search through those pages thoroughly to determine which lead to Jupiter radio astronomy data. The NSSDC archives Jupiter radio astronomy data, but it is not listed among the Webcrawler search results because it cannot describe each of the thousands of data sets contained in the NSSDC on Web pages. There is the additional problem that there are still many data and information sources that are not yet a part of the Web.

## Directory usage with standards

Information professionals, such as librarians, are using the Web and other network tools to benefit their users. Many prefer, however, to search for specific topics through services such as Dialog, where the information has been put into standard form and a search is likely to yield a more complete set of information. The NMD stores information in a standard form called the Directory Interchange Format or DIF. The DIF requires a description of data sets to have controlled keywords attached in particular fields. Use of the controlled terms in a search yields a higher probability that the results are comprehensive in the subject area.

The problem with the standardized information sources is the amount of time and effort it takes to put information into the standard form. To create a DIF requires minutes to hours, depending on the amount of detail included, for a person familiar with the data being described and the DIF format. For a person unfamiliar with the DIF format it can take a day or more to understand the DIF and then write one. Thus, it takes cooperative effort and dedicated attention to gather standardized information from a wide variety of sources. The NMD has been made as comprehensive as possible with respect to NASA-funded data, but the NMD also includes descriptions of space science data from other sources in the world. It is difficult to put all of that information in the DIF format. There are compromises, however, which can help to alleviate this problem.

## WAIS directory searches

Overview information about data sets exists in many directories around the world and the content of this information does not differ greatly from one directory to another. Many of these directories exist in electronic form. It is not too difficult to gather the directory databases in a central location and use WAIS or similar indexing software to provide a text-search capability into the accumulated information. This differs from generalized WAIS searching of the Web because the gathered information is limited to directory information on a particular subject, such as space science data. For example, there is a WAIS searching capability available in the NMD and the entry of the keywords “radio,” “astronomy,” and “Jupiter” quickly yields a list of data sets relevant to that topic and the information about where they are located. Again, the success of searches depends on the commonalty of terminology used in the directory entries. To make searches more likely to yield comprehensive information, it may be necessary to provide some “added value” to the databases by attaching keywords chosen from standardized lists. The simple attachment of keywords would not require as much effort as the restructuring of the information into the DIF format. For data sets that were considered to be particularly useful or important the full process of DIF creation could be followed and the data set would then be retrievable by the wider variety of search techniques available through the traditional NMD.

## Distributed directory searches

Even with the simplified process of gathering all forms of directory databases into a single text-searchable database it is still difficult for any one organization to gather comprehensive information and keep it up to date. It would be better if each of the sources could keep their information at their location and update it as changes or new additions occur. The Committee on Earth Observing Satellites International Directory Network (CEOS IDN) is a federation of network-connected directory database nodes that share information with each other in the DIF format. One future scenario calls for users to be able to log into any of the directory nodes and submit a search query that would be sent to many or all of the nodes and return results to the original node. Then each node need only have a database of information describing the data sets in its domain. Even if there are not enough local resources to put the information in the DIF format, general text descriptions could be gathered and made text searchable through the WAIS distributed server techniques. The advantage of this approach over simple Web text searches is the narrowing of the search domain to directory information in specific subject areas only. Again, the addition of controlled keywords to the entries in the databases could make the search even more effective.

## A revolution

The Web has brought a revolution in the ease of access to a wealth of information. It has not, however, replaced the need to assemble information about specific subject areas and to make that information specially findable through standardized techniques. NSSDC’s NASA Master Directory offers this value-added service in the search for NASA-funded data and will continue to gather information on important space science data sets worldwide. This service is readily available to Web users. With an increased use of text-searching techniques on less rigidly formatted information and potential cooperative effort by distributed data information sources, the service can be made even more useful for the community. It is still important to have as much commonalty as possible in the databases being searched. The amount of commonalty incorporated will depend on resources available, but newer search tools are lessening the amount of effort required. You are invited to try the present system and send in your suggestions for improvement.

The NASA Master Directory is accessible at <http://nssdc.gsfc.nasa.gov/nmd.html>.

The directory is also located in the NSSDC Online Data and Information Service and is accessible via Telnet or DECnet:

- Telnet: NSSDCA.GSFC.NASA.GOV
- Username: NODIS
- DECnet
- $ SET HOST NSSDCA
- Username: NODIS ■

# The NASA Web: User Feedback

***April Marine, Network Applications and Information Center, Ames Research Center***

***"I love being able to reap the benefits of the space program directly. This is a real treat."***

***"Remarkable"***

These are just two comments received about the Guide to NASA Online Resources. The Guide is compiled by the Network Applications and Information Center (NAIC) and has been available as a World Wide Web and Gopher resource since the spring of 1994. The welcome page for the Guide is accessible from the URL <http://naic.nasa.gov/naic/guide/>

## What is the Guide?

The Guide to NASA Online Resources is a compilation of information about many online resources and services made available by NASA organizations or of interest to the NASA community. It was designed to be one way of alerting new users of the NASA Science Internet to the wealth of resources they can access via their network connection. However, the Guide also serves as a general network entry point to much of the information NASA offers the online community.

The Guide as a Web resource is in a slightly different format from many other Web pages listing NASA resources, such as the "NASA Information Sources by Subject" listing available from the NASA Home Page <http://hypatia.gsfc.nasa.gov/NASA_homepage.html> or the Langley "NASA Online Information" page <http://www.larc.nasa.gov/larc.html>. The NAIC requests that contributors to the Guide fill out a brief template describing their service, how to get to it, and whom to contact for more information. This template approach is more work for both the contributors to the Guide and for the NAIC, than creating a page of links would be, but the advantages to creating the Guide this way are threefold.

- It allows the NAIC to create a searchable index of information from the descriptions and keywords included on the templates.
- It allows you to review a brief introduction about a service to judge whether you want to select the link to it.
- It allows the NAIC to more easily compile the information into several formats.

Since June, the NAIC has made available an online feedback form so that Web users can enter their impressions of the Guide. If you would like to look at the form online, it is available at <http://www.?>

## Feedback to the Guide

The NAIC received 74 responses offering feedback from June through October, with the overwhelming response being positive. This is especially heartening because the positive comments received were as much about the NASA resources the Guide describes and links to as they were about the Guide itself.

In all its interactions with users, the NAIC has noted that people continue to expect all types of information to be available online—not just information about traditional concerns found in a networkiing environment, such as software or database access. One of the NAIC's most frequently asked questions concerns online access to NASA job postings. (NAIC FAQs and their answers are also available via the Web from the NAIC Home Page at .

The NAIC has found the Web feedback form mechanism to be an extremely useful way of communicating with people. Because the form requests users' names and email addresses, the NAIC was able to respond with further information individually to those users who were frustrated in finding information via the Guide. Many other users took advantage of the online form to send the NAIC questions or suggestions, some of which had nothing to do with the Guide, but each of which we were able to respond to as well.

## The future

The NAIC will continue to solicit contributions to the Guide so that it can evolve into a fuller representation of NASA information.

The NAIC is also excited about the recent formation of a “Webmasters” working group as part of the Intercenter Council on Computer Networking (ICCN). This working group will address topics related to creating a “well-structured, user friendly NASA Web.” The feedback received about the Guide to NASA Online Resources shows that users view NASA’s online resources as a whole, rather than as discrete efforts. The Webmasters working group will provide a forum for NASA information providers to work together to maintain NASA’s reputation for having the best Web system on the Internet. Information about NASA Webmasters’ activities can be found on the Web at <http://ice-www./arc.nasa.gov/webmaster>.

*Finally, the NAIC is grateful to all contributors to the Guide. If you would like to contribute, there is an online template you can use to do that as well, accessible as a link from the Guide’s welcome page.* ■

# Global Change Master Directory now on the Web

***John Scialdone, Hughes-STX and Archie Warnock, A/WWW Enterprises***

On August 1, 1994, the Global Change Master Directory (GCMD) Home Page made its debut on the World Wide Web (WWW) as part of an effort to provide access to global change/Earth science data and information. Features include direct-querying via controlled fields and free-text Wide Area Information Servers (WAIS) searches of the directory, GCMD news, lists of data sources, and GCMD documentation. The construction and maintenance of the GCMD Home Page and underlying hypertext links is a high-priority activity of the GCMD staff, with new information being added on a regular basis.

## Access

The GCMD Home Page can be accessed using WWW browsers such as Mosaic or MacWeb and the URL address <http://gcmd.gsfc.nasa.gov/>. Mosaic and MacWeb provide a ‘Forms’ capability whereby you can submit queries directly to the GCMD database from the Home Page. The GCMD client can also be accessed via telnet gcmd.gsfc.nasa.gov. and login as ‘gcdir.’ The client will recognize your workstation and give you the X-window or ASCII interface.

In order to provide the WAIS-search option, the entire contents of the GCMD were extracted into ASCII files and indexed using the ‘waisindex’ program from the freeWAIS v0.3 release from the Clearinghouse for Networked Information Discovery and Retrieval. Future enhancements will include fielded searching (so you can search on only title, source or sensor), and inclusion of active hypertext links in the returned directory interchange formats (DIFs).

The Committee on Earth Observing Satellites International Directory Network is accessible through the Home Page and consists of three coordinating nodes on the American, Asian and European continents, each maintaining a complete copy of the GCMD database. The European coordinating node is operated by the European Space Agency in Frascati, Italy and the Asian coordinating node is operated by the National Space Development Agency of Japan.

## GCMD news

The news area of the Home Page emphasizes the newest data set entries, ‘hot’ research topics, and the latest news on the GCMD. The data set entries section lists the previous and the current months’ data sets loaded into the GCMD by title. The ‘hot’ topics section highlights important areas of global change/Earth science research and associated data sets. These include Greenhouse Gas data sets, National Climatic Data Center Ultraviolet Index forecasts, Antarctic Ozone Values from the British Antarctic Survey, and El Nino/Southern Oscillation predictions, analysis and advisories. The latest news section features meetings to be attended by GCMD staff and electronic bulletin board systems with global change/Earth science information. The GCMD will be demonstrated at the upcoming American Meteorological Society meeting, January 14-20, 1995, in Dallas, Tex. Future news will include GCMD upgrades and interface announcements.

## Global change data sources

The data sources area provides hypertext links to Earth Observing System (EOS) data and information, and servers with global change/Earth science data and information. The EOS section provides access to the EOS server, EOS Data and Information Core System (EOSDIS), and the Mission to Planet Program (MTPE). The MTPE project descriptions and data include the Sea-viewing Wide Field-of-View Sensor, Tropical Rainfall Measuring Mission, Advanced Very High

Resolution Radiometer, Geostationary Operational Environmental Satellite Pathfinder Data, and the Moderate Resolution Imaging Spectrometer Airborne Simulator. Access to the EOSDIS Version 0 Information Management System (IMS) Home Page is provided, as well as hypertext links to all EOS Distributed Active Archive Center (DAAC) Home Pages.

Access is also provided to over 100 home pages and servers covering a wide variety of Earth science/global change data holdings. Hypertext links are provided for servers grouped under broad categories. The categories include climate, greenhouse gases and meteorology; oceanographic data; ecosystems and land data; weather and forecasts; satellite data; federal agency and international organizations; and useful information resources.

## GCMD documentation

This area gives details on the DIF, the existing format for GCMD data set descriptions, and a proposed 'new' keyword structure. The DIF has been adopted by the Interagency Working Group on Data Management for Global Change for the exchange of directory-level information. The DIF contains 24 fields of which six are required. The proposed keyword structure is the result of a requirement to be compatible with the EOSDIS IMS and the local DAAC IMS systems, and will continue to evolve as new data products are introduced.

## Other points of interest

The last area of the Home Page contains hypertext links to the NASA Global Change Data Center and National Center for Supercomputing Applications Home Pages, as well as the Federal Geographic Data Committee (FGDC) Content Standards for Digital Geospatial Metadata. The FGDC has been chartered to coordinate spatial data activities of federal agencies and geospatial data activities with other levels of government. Because of this initiative, the entire DIF-based GCMD will evolve to become compliant with the Spatial Metadata Standard, which contains about three times as many fields as the DIF.

The GCMD project originates from the Goddard Space Flight Center, Global Change Data Center, in Greenbelt, Md. For additional information contact John Scialdone at: (301) 441-4214; <scialdon@gcmd.gsfc.ansa.gov>. Archibald Warnock can be reached at: (301) 854-2987; <warnock@clark.net>. The GCMD User Support Office can be reached at (301) 441-4202. ■

# New Cosmic Background Explorer Data Available

**Dave Leisawitz, Goddard Space Flight Center**

An initial set of Cosmic Background Explorer (COBE) data products was delivered to the National Space Science Data Center (NSSDC) for public access in June 1993. The Initial Products and accompanying documentation and images are now in the hands of over a thousand researchers, educators, and other curious individuals. To date, 29 investigators have been funded or otherwise approved under NASA's Astrophysics Data Program as COBE Guest Investigators. Well over 100 others who lack such support have conducted serious research with the COBE data. More than 800 scientific papers now in the literature—10 times the number written by the instrument Principal Investigators or other members of the COBE Science Working Group—either present, interpret, or directly depepend upon COBE results. Indeed, it's unusual to find a cosmology paper that does not refer to COBE.

The COBE Project Data Sets are now publicly accessible from the NSSDC. The new data products augment their predecessors and include some calibration refinements. Specifically, the Project Data Sets provide all-sky, full spectral range Diffuse Infrared Background Experiment (DIRBE) and Far Infrared Absolute Spectrophotometer (FIRAS) coverage; DIRBE polarimetry, and the first two years of Differential Microwave Radiometer (DMR) data. Calibrated, time-ordered data are also available. The DMR Project Data Sets were released in June 1994; the DIRBE and FIRAS Project Data Sets were released in early October.

All of the files were made accessible from the NSSDC's anonymous ftp site within a couple days of their receipt, except for the time-ordered data, the DMR pixel-sorted data, and the DIRBE Weekly Sky Maps. CD-recordables containing the DMR pixel-sorted data and the DIRBE Weekly Sky Maps were produced within a couple weeks of the data delivery dates. Two more CD-recordables are planned, one replicating the DIRBE files kept online and another replicating the FIRAS files kept online, including a supplementary set of FIRAS files due to be delivered in November. All of the data, including the time-ordered data, are available on 8mm or 4mm tape. Like the Initial Products, most of the Project Data Sets are presented in Flexible Image Transport System (FITS)-format binary tables.

For overviews of the new COBE data products, see the COBE Home Page at <http://www.gsfc.nasa.gov/astro/cobe/cobe_home.html>.

Click on "About the data products" or download the files dmr_pds_products.doc, dmr_asds_products.doc, dirbe_pds_products.doc, and firas_pds_products.doc from the COBE ftp directory.

If there is sufficient interest from the scientific community, and if funding permits, additional data products designed to enhance the utility of the Project Data Sets will be developed. For example, a set of zodiacal light subtracted DIRBE maps would greatly facilitate analysis of extra-solar system sources of infrared emission. To register your interest in such additional data products, or for further assistance contact the author at: 301-286-0807; <leisawitz@stars.gsfc.nasa.gov>.

More information about the COBE mission and instruments is available either by anonymous ftp in the "cobe" directory at nssdca.gsfc.nasa.gov (128.183.36.23), <http://www.gsfc.nasa.gov/astro/cobe/cobe_home.html>. (The latter is recommended if you have access to a Mosaic client.)

## Acknowledgment

The COBE data sets were developed by the Goddard Space Flight Center under the guidance of the COBE Science Working Group and provided by the NSSDC. ■

# Astronomical Conference Furthers Communication Among Software Developers and Scientific Users

*Eric Mandel, Smithsonian Astrophysical Observatory and Don Jennings, Goddard Space Flight Center*

The Fourth Annual Conference on Astronomical Data Analysis Software and Systems (ADASS) was held in Baltimore, Maryland in late September. The ADASS conference series provides a forum for scientists and software developers who are involved in the reduction and analysis of astronomical data. A key objective of ADASS is to encourage communication between software developers and scientific users. Another key aim is to expose the astronomical software community to concepts and techniques from other areas of computer science.

The key topics for the conference centered on Astronomical Data Modeling and Analysis, Design and Development of Graphical User Interfaces, Network Information Systems, and Parallel and Distributed Processing. More than 100 oral and poster papers were presented at the conference on these and other topics. In addition, special interest sessions were held on the topics of the Flexible Image Transport System, the Image Reduction and Analysis Facility (IRA) Site Management, DL, Data Acquisition, GUI Development, and software from the Hubble Space Telescope, ROSAT and Extreme Ultraviolet Explorer missions. Finally, "tag-along" workshops on the electronic distribution of preprints and on IRA software development were held on the day following the conclusion of the conference.

Many ADASS presentations were relevant to the aims and interests of the NASA information systems community. For example, Carol Christian (Center for EVE Astrophysics/CU Berkeley) made a presentation entitled "Architectural Framework Model Applied to the NCSA Mosaic and Astrophysics Data System Interpretability," which described interoperability between the NASA Astrophysics Data System and NCSA Mosaic. The abstract describes this far-reaching work as follows:

The new system being created, which will enable the Astrophysics Data System and NCSA Mosaic to interoperate, will be mapped onto an architectural framework. This framework has been adopted by the National Information Infrastructure Testbed and the cross-industry working group as a tool to examine distributed computing systems. The framework is used to evaluate particular attributes of a distributed system to identify types of components required, desired, or not needed for a particular application. The purpose of the study is to understand the underlying middleware by applying the framework to the system being examined, rather than to critique the framework model (which is adaptable and evolutionary). Results of the study as presented here aim at clarifying the key issues that lead to architectural design decisions in deploying such systems. Areas that translate to non-domain-specific distributed systems are identified in the process and communicated to other application developers. This work is supported by NASA contract NAS5-30180.

A new view of distributed computing and archiving was presented in a poster paper entitled "SkyView as an Archetype of Archival Systems of the Future," by Tom McGlynn, Nick White, and K.A. Scollick (Goddard Space Flight Center). An excerpt from the abstract describes their distributed approach to archiving astronomical information.

In the next decade the availability of astronomical data to astronomers will grow at an unprecedented rate. Simultaneously the availability of increased network connectivity and cheap distribution by CD makes existing resources far easier to access. To deal with this exciting but potentially bewildering array of information, our community must begin to build interfaces of a new kind, with an intrinsic understanding of basic astronomy.

The SkyView virtual represents a new approach to the archiving of astronomical information. SkyView has taken 15 all-sky or large area surveys in wavelengths ranging from radio to gamma rays and provides the data in a convenient, easy-to-use form. Astronomers need not concern themselves with the geometric issues of projections, coordinate systems, resampling--these are addressed automatically and largely invisibly to the user.

In a paper entitled "Applying Public Access Programming Techniques To SAOimage," Eric Mandel presented the status of ongoing efforts to make different analysis systems and programs work together more effectively in an extensible, "open systems" environment.

This paper describes our application of the X Public Access (XPA) interface to the new version of SAOimage. XPA allows data in an Xt program to be tagged with string identifiers and then accessed externally by other programs. The new SAOimage uses this interface to "externalize" many of its internal algorithms, including file access and scaling. Such an architecture allows users and developers to support new file formats and scaling algorithms without modifying the core image display program itself. XPA also makes possible the external control of SAOimage's main functions, including image display, image zoom and pan, color map manipulation, cursor/region definition, and frame selection. Thus, SAOimage now can be controlled from the command line or from batch files. It also can be interfaced easily with external software environments such as the Astrophysics Data System. Finally, we describe how SAOimage uses XPA to support user-configurable "quick-look" analysis of imaged data.

Significant work in the development of Graphical User Interfaces (GUIs) was presented by Don Tody (National Optical Astronomy Observatories) in his paper entitled "A Portable GUI Development System." Excerpts from his abstract describe a GUI development system that combines the flexibility of a high-level scripting language with toolkit and window system independence.

We describe a new GUI development environment which extends the Xwindow system and the X Toolkit (Xt) with a high level, object-oriented, interpreted programming language based on Tcl to allow GUIs written using industry standard Xt-based widget sets to be constructed without requiring any window system programming on the part of the programmer. The architecture of the resulting program completely separates the GUI from the applications code, allowing the GUI to be developed separately and replaced at will, and allowing an application module to be used with multiple alternative GUIs without recompilation. Despite the separation of the GUI from the application the two are tightly integrated using a formal messaging system based on requests and asynchronous client events, with the client application appearing as just another class of object within the GUI. This approach maximizes window system and toolkit independence and is well suited to distributed applications since the system is message based and inherently asynchronous, allowing the GUI and client application to easily be run on separate processors or computers.

Finally, the requirement that our work reach beyond the boundaries of the astronomical community was stressed by Robert Brown (Space Telescope Science Institute) in his paper entitled "Educational Electronic Products Based on Astronomy Research."

The Internet and CD-ROMs have created new opportunities for the ideas and results of astronomical exploration to be communicated to the public, especially students and teachers. We discuss the ExInEd program at STScI as one example of how these opportunities can be developed, including our technologies, relations with authors, distribution channels, and authors. We will illustrate our products, discuss how they operate, and how they were made.

ADASS proceedings are published as part of the American Society of the Pacific conference series. The entire program is available at <http://ra.stsci.edu/ADASS.html>.

For additional information contact the authors-Eric Mandel <eric@cfa.harvard.edu> or Don Jennings <jennings@tcumsh.gsfc.nasa.gov>. ■

# The Making of the IGARSS '94 Proceedings CD-ROM

***Mike Martin, Ann Bernath, Jet Propulsion Laboratory and Mark Takacs, Sterling Software***

The International Geoscience and Remote Sensing Symposium (IGARSS) '94 was held at Caltech, in Pasadena, California, in August. It was attended by about 800 scientists, and the agenda included nearly 100 sessions with 10 presentations per session. For the first time, the conference proceedings were provided on a CD-ROM disc instead of the traditional hard-copy format. Attendees had to specifically request (and pay $65) to purchase the four-volume, 15-lb. printed proceedings (440 attendees did so).

The IGARSS CD challenge was to provide equivalent content to the printed proceedings on a CD-ROM disk. Anyone familiar with electronic publishing will understand that this is a significant and possibly impossible challenge. The display size of a computer screen varies from 640 pixels (wide) by 480 pixels (high) to 1024 by 768. A printed page needs to be scanned at about 300 dots per inch to provide an adequate rendition that results in an image size (for an 8-1/2 x 11 inch page) of 2550 by 3300 pixels. Thus a standard computer display can view only a pathetically blurry version of an entire page, or a full-resolution version of a tiny part of a page. With this realization in mind, the requirements for the IGARSS CD-ROM were limited to the following:

- provide all abstracts in full-text form with some text search capability to assist in locating papers of interest
- provide monochrome scanned versions of all papers and a mechanism to print on demand the scanned papers
- include author submissions of gray scale or color images

The final architecture of the CD-ROM exceeds most of the objectives:

- provides the full text of all abstracts via Mosaic, but not with full-text search on the CD-ROM; rather specialized indexes were provided by author, paper number, topic
- provides papers in Adobe Acrobat Portable Document Format (PDF) in one of several forms accessible through the Mosaic interface (one paper at a time) or in a 3550-page PDF file, which includes the table of contents with hyperlinks to the papers and bookmarks that outline the conference agenda. The formats of the papers may be any one of the following:
    - documents just as the author prepared them (many of these are truly magnificent examples of what electronic publishing can be)
    - stripped down versions of the above, missing the graphics and images, which may be available through the Mosaic interface
    - monochrome scanned Tagged Image File Format (TIFF) images of each paper, in acceptable, but not great quality due to paper scanning procedures

- strange-looking renditions of the papers interpreted by Image Alchemy from Postscript files and presented in image format, rather than text.
- author submissions or gray scale of color images for viewing via Mosaic helpers

The IGARSS challenge was exacerbated by the desire to support three computer platforms (Macintosh, Windows and UNIX workstations) with the same, or at least a similar, interface. Most conference proceedings to date rely on delivery software that works on only MS-DOS or Windows-based platforms. The science community, however, is pretty evenly divided across the selected platforms. The delivery mechanisms chosen (Mosaic and Adobe Acrobat) work consistently across the target platforms.

## Abstract processing

Optical Character Recognition (OCR) was performed on approximately 1100 abstracts using a Kurzweil 5200 OCR system. About 50 abstracts were OCR'd at a time, with each batch taking about 30 minutes. Ninety percent of the resulting text files contained only minor errors and could be hand-edited in about 3 minutes per abstract. The major difficulties in abstract processing were the formatting of author names and addresses and the use of embedded mathematical symbols (despite requesting that authors not put them in abstracts).

## Bad abstracts

About 120 abstracts contained so many errors that the editors felt it was easier to retype the whole page (7 minutes per abstract). Instead of this massive retyping, we decided to try an experiment. The abstracts were rescanned on Kodak Scanner/Microimager 990, which provides 120 page-per-minute throughput and can scan both sides of a document simultaneously. The scanning took just a few minutes. The scanned pages were then OCR'd with two different OCR programs (WordScan and OmniPage). The resulting text files were compared using a Macintosh program called DocuComp II. This program merges all the identical text and highlights the differences. Incredibly, the combined success rate of the two OCR programs was close to 100%. It then took only a few minutes per abstract to discard incorrect text. This technique was summarized in the article “Improving Optical Character Recognition Performance'' in the April 1994 issue of this newsletter.

## Hard-copy paper processing

The papers were received in random order in various sizes, but mostly 8-1/2 x 11 pages. The first step was sorting the 720 papers into some order prior to scanning. The scanning was done on the Kodak Scanner/Microimager 990 scanner that was used to scan the bad abstracts. The scanning process was similar in complexity and speed to inserting a stack of pages into a photocopier and pushing the ‘'start'' button. However, the secondary processing to produce our TIFF output files took more on the order of 20 seconds per page (3 pages per minute). This was substantially slower than the abstract conversion, due to the greater information density of the pages. The resulting TIFF files were about 38 kilobytes per page.

## Scanned paper processing

The scanning resulted in 2250 TIFF images that had to be converted to 720 PDF files. Nearly a third of the TIFF files scanned on the Kodak scanner were not readable when processed on the Sun workstation. These files were rescanned on the Kurzweil 5200 at 400 dpi. This produced images that were too large for Acrobat (which is limited to 2048 pixels). These files were converted to 300 dpi with image alchemy. The first time these PDF files were scrutinized was when the first review CD was made. Unfortunately, the conversion from 400 dpi to 300 dpi had rendered many of the pages unreadable. The conversion had to be redone using optimization options that produced acceptable 300 dpi images.

## Electronic submissions

Electronic submissions were received by anonymous ftp, e-mail and on floppy disks. A special ftp site and a special IGARSS e-mail account were set up for the incoming IGARSS submissions. Approximately 153 papers were submitted electronically via ftp and e-mail. Nearly 125 more were submitted on floppy disks (70% PC, 30% Mac).

Electronic submissions were idenTIFFied by paper number (a sequential number assigned to abstracts as they were received), author name, title and session id (a concatenation of day, time, room and sequence number). An explicit scheme for labeling submissions should have been specified in the author instructions. Several hours of unnecessary detective work were required to track down the proper paper numbers. The files received for each paper were placed in directories named by the paper number. Where available the e-mail addresses of the authors were kept in case questions arose later.

The e-mail and ftp directories needed to be watched over carefully. Unfortunately, during a business trip the e-mail directory filled up the file system and was deleted in the ensuing recovery process. The nightly backups that were being performed turned out to be capturing only a static part of the file system not the e-mail directory. It was embarrassing to have to request that the authors resend electronic submissions submitted for that period of time.

We had asked authors to submit Postscript files and/or ASCII text. Many also submitted word processor files, which turned out to be beneficial when some Postscript submissions could not be processed. They were also allowed to submit up to one megabyte of images or other data files in any format they desired. These supporting files were placed in the directory with their associated paper, and in some cases the image files were converted to a standard format such as GIF. Some authors sent TeX and LaTeX files. One author sent a GML file that was easily converted to HTML (HyperText Markup Language). In fact, we were able to convert 18 papers to

HTML. These papers were totally integrated with the rest of the Mosaic interface and did not require launching the Acrobat Reader.

## Postscript file processing

Each Postscript file had to be run through the Adobe Acrobat Distiller program to produce a PDF file. There is a way to distill multiple Postscript files into one PDF, which might have been useful had we known about it early in our processing. Of the 283 papers received in Postscript format, 122 distilled correctly, 63 produced fatal errors, 60 resulted in papers that displayed so slowly as to be unusable, 26 were clipped (only a portion of the page was displayed) and a dozen or so were otherwise damaged in bizarre ways. Through a variety of tedious methods about 48 of the bad papers were rescued.

For some of the bad Postscript files we also had the word processor files used to generate the Postscript. In these cases we opened the files with Microsoft Word then printed to the PDFWriter printer driver. This technique allowed us to salvage a handful of the bad PDF files.

The rest of the bad Postscript files were processed with Image Alchemy PS, (one page at a time) to produce PDF pages that were then concatenated into PDF papers. A good portion of these had to be rescaled during the conversion so they would load in Adobe Acrobat Exchange without an out-of-bounds error. In this recovery effort, only the black and white conversion was successful. Trying to convert Postscript files containing gray scale or color resulted in incredibly large files per page that were essentially unusable. Unfortunately, as a result, potentially beauTIFFully rendered Postscript papers were reduced to black and white because of Adobe Acrobat's inability to process them through their Distiller product, and Image Alchemy PS's inability to produce a usable color file.

## Mosaic interface

The IGARSS Home Page presents a variety of information about using the CD-ROM, about the conference and a set of menu access paths to get to the papers. The abstract for each paper serves as that paper's ‘’home page,’’ a stable central access point for all the information submitted with that paper. The abstract/home pages were automatically generated via a Perl script that made revisions and style changes trivial. The script examined each paper's directory and constructed links to all files submitted with that paper. These often included the full-text PDF files, ASCII text-versions, code-fragments, and images or figures in GIF, JPG, or EPS format.

When you select a paper from one of the access paths the abstract text is displayed with an iconic link to the paper (stored in Acrobat format) and a menu of files submitted by the author. Selecting the paper link launches Adobe Acrobat and displays the paper. The Acrobat display ranges from excellent for papers that were formatted for a computer screen to miserable for many of the scanned papers. The key value Acrobat provides is the ability to preview then print papers of interest. The printed copy is a faithful (if not pretty) rendition of the contents of the original proceedings.

## Customer response

During the conference, both the Adobe Acrobat interface and NCSA's Mosaic interface were available to users to browse the IGARSS ‘94 CD-ROM. A number of conferees used the CD to determine their agenda for the day. The majority of users preferred the Mosaic interface because the information on the screen was easier to read and the access paths were more obvious. Traversing the Acrobat document was not intuitive and users could became lost in a sea of concatenated pages. It should be noted that Acrobat could support building access paths like those found in Mosaic, but only with a great deal of manual hyperlinking.

A major problem reported by CD users was the fact that only one UNIX platform, SunOS, could use the Acrobat Reader. HPs, SGIs, and other hosts could navigate within Mosaic, but they could not view the papers. Some Solaris users also had problems, even though we had successfully used the SunOS binary on a Solaris machine.

The online World Wide Web server was used regularly before, during, and after the conference and continues to be used as of this printing. There were spikes before and after the conference as people explored what they might anticipate at the conference and when they returned home and consulted the online version.

For the peak usage week, accesses were split between .gov, .com and European sites, with European and gov sites registering high consistently through all the weeks. Updated statistics are available at <http://stardust.jpl.nasa.gov/igusage>.

## Resources

The planned IGARSS CD-ROM budget was $12K for labor and $12K for CD production (two CDs were initially planned, but only one was produced). The actual cost was $12K for labor, $2K for a 2-gigabyte hard disk (which proved invaluable) and $5K for the 1700 copies of the CD, including a 12-page color brochure. Digital Audio Development Corp. did the brochure, CD mastering and replication, and provided a two-day turn-around at the seven-day turn-around price.

About another $8K of labor was provided by the Jet Propulsion Laboratory's Data Distribution Laboratory staff or voluntarily contributed on weekends and evenings in order to produce a great product. A rough estimate of three person-months is probably close to the total effort. A breakdown of the hours spent on individual tasks can be found in an expanded version of this articlr at <>.

The software used in the production of the IGARSS conference proceedings included: Adobe Acrobat Reader, Exchange and Distiller 1.0; NCSA Mosaic; WAIS; Image Alchemy (Sun version); UserLand Frontier (Mac); QuicKeys (Mac); FoxPro (Mac); Perl (Sun); Word (Mac); and MacLink Plus (Mac).

## Conclusions

The IGARSS CD-ROM team feels that the CD-ROM provides at least a glimpse of what electronic conference proceedings can be. It's not everything we wanted but it exceeds anything we've seen before in content and scale. Over 700 abstracts and papers are available in a form equivalent to the printed proceedings (scanned pages). Several hundred papers are available in full electronic form, including many color submissions that are not found in the printed proceedings. The resulting CD-ROM is literally a treasure of readily accessible knowledge with supporting digital data sets that can be applied to almost any area of remote sensing or science education.

Copies of the IGARSS CD are available from:

The Institute of Electrical and Electronics Engineers, Inc.
445 Hoes Lane
P.O. Box 133
Piscataway, NJ 08855-1331

## Suggestions for future IGARSS CDs

These are some of the things that would be done differently if another IGARSS CD-ROM was produced.

- Require electronic submissions of abstracts with tags for automated processing. Mandatory tags should include paper number, title, authors and abstract text.
- Specify 8 1/2 by 11 inch page size for Postscript papers.
- Urge submissions in a few selected word processor formats, provide style sheets to authors.
- Include Postscript files on the CD-ROM for users to print or view.
- Keep a database of electronic submissions, their formats, the e-mail addresses of the authors, etc.
- Do your own backups (Trust no one.).
- Request ftp or media instead of e-mail submissions, or set up a mail daemon to handle submissions on a daily basis.
- Make sure you have a review staff with time to do the review.
- Make sure you can comply with licensee/customer review requirements or get a waiver. We had a signed agreement with Adobe to allow 14-day review, which could have been a disaster if they had enforced it.

*NOTE: NCSA informed us in September that our use of the Mosaic binaries on the CD-ROM requires commercial licensing through Spyglass. Spyglass will license the software for $.50 per copy for under 5000 copies, $.30 for over 5000. The fee would be $850 for the 1700 IGARSS CDs that were pressed. We are still discussing the license arrangement with IEEE, who holds the copyright and owns the intellectual property.*

The IGARSS contents are accessible online at URL: stardust.jpl.nasa.gov/igarss

IGARSS Before


IGARSS After

For additional information contact Mike Martin at: 818-306-6038. ■

# New Supercomputing Facilities Open at Goddard

***Jarrett Cohen, Hughes STX Corp., High Performance Computing Branch, Goddard Space Flight Center***

A ribbon cutting ceremony on October 19, 1994 opened the new NASA High Performance Computing and Communications (HPCC) Guest Computational Facilities at Goddard Space Flight Center (GSFC). Speakers at the event included Milt Halem, chief, Space Data and Computing Division; Dorothy Zukor, deputy director, Earth Sciences Directorate; John Klineberg, director, GSFC; and Lee Holcomb, director, NASA Office of High Performance Computing and Communications.

The facilities are part of the HPCC Earth and Space Sciences Project, which is aimed at accelerating the development and application of high-performance computing technologies for tackling NASA's Grand Challenges. Current efforts include probing the formation of the large-scale universe; modeling the global climate system in the past, present, and future; ascertaining the dynamics of the interior of stars; and indexing and searching through massive Earth-observational data sets.

The renovated wing houses testbed computing systems, visitor space for collaborators from the 120-investigator Grand Challenge teams, and an interface to a high-speed network.

Current Goddard-resident testbed systems include a 16-processor Convex Exemplar SPP-1 and a 4-node MasPar MP-2/MP-1 cluster (32,000 total processors), which were installed this year. These and other systems at sites throughout the nation provide a variety of scalable parallel platforms on which to develop Grand Challenge applications. In late 1995, Goddard will acquire a major next-generation parallel testbed through a multimillion-dollar Cooperative Agreement Notice. Also located in the new facilities is an interface to the 2.5-gigabit-per-second Advanced Technology Demonstration Network. This prototype of the National Information Infrastructure connects six federal laboratories in the Washington area. A virtual reality laboratory was also recently installed. ■

# Serving up the Planetary Data System to the Internet

***Ann Bernath, Planetary Data System, Jet Propulsion Laboratory***

A common user interface? Nearly a decade ago the implementation of the Planetary Data System (PDS) catalog's user interface was the subject of long and loud discussions. To the newly formed Version 1.0 Development Team and members of the PDS Science Working Group, the requirements seemed contradictory.

- The user interface should be common across all PDS nodes because it would be a distributed system.
- The interface should be compatible with any computer platform.
- PDS should also lead the way in developing standards and exploring technologies for cataloging, searching, retrieving, distributing and archiving planetary data.
- The implemented system should not require the users of PDS, the planetary community, to purchase expensive software

In 1985, the options for meeting all of these requirements were limited.

## Initial system

Version 1.0 of the PDS Data Set Catalog became operational in March 1990. It was a VT-100-based user interface because most platforms could emulate a VT-100. The requirement for an inexpensive, common user interface was implemented using Transportable Applications Executive (TAE), a public domain software package already in use within NASA.

Many believed that TAE was too plain and too limited, yet in an effort to provide an umbrella over the physically separate and functionally disparate nodes of the PDS, TAE was used as the identifying banner, or "golden arches," at each site.

As time went by, the user interfaces of PDS catalogs and other online systems at the various PDS nodes began to diverge. Even the Central Node at Jet Propulsion Laboratory (JPL) abandoned TAE and replaced their user interface entirely. Although providing access to the other nodes, there was no longer a common umbrella.

Also, a great deal of what PDS had accomplished and contributed to the planetary community was not available through these online systems. The time between 1985 and 1990 was not spent solely building a user interface, it was spent designing a common, cross-discipline, planetary science data dictionary. Archive-quality data set standards such as content, organization, format, documentation and the labeling of planetary data were developed so that future users of the data could retrieve and use the data reliably. This critical information needed to be distributed to data preparers, such as flight projects. Although some of the information was available electronically to those with a PDS user account, most information was distributed by the traditional, often inefficient, and out-of-date medium of paper documents.

## Enter the Internet

The Internet has become a daily lifeline to computer users. Internet tools such as Archie, Gopher, and File Transfer Protocol (ftp) set a brand new paradigm for finding, retrieving and making data freely available without the need for special user accounts. Both client and server software for these tools became free for the downloading. Clients and servers became available for practically every platform. Wide Area Information Servers (WAIS) gave information providers an inexpensive, and easy-to-use method for distributing their data.

As an experiment, the PDS Central Node put up a WAIS server. Planetary data set metadata from the catalog, the planetary science data dictionary, catalog submission templates, and the Standards Reference and Data Preparation Workbook documents were made available online for full-text search access. These WAIS data sources were later officially registered at the Directory of Servers, enabling anyone with a WAIS client to discover that the PDS had metadata about planetary science data and standards by which to catalog and archive that data. For the first time, it became easy to see how all aspects of PDS worked together.

## New umbrella

Since the National Center for Supercomputing Applications released its Mosaic product, the use of the World Wide Web (WWW) has taken the Internet by storm. Mosaic's multi-client, easy-to-use hypertext interface allows easy navigation of information pages, provided by the same server, or distributed servers. Because of Mosaic's versatility, a Mosaic client can provide access to WWW servers, WAIS servers, ftp servers, news servers, or custom-built servers, all in a single user interface.

Multimedia access is provided by identifying helper applications to display certain file types. For instance, clicking on a hypertext link to a file with the extension ''gif'' will launch a gif display package. A file with the extension of "au" will launch an audio package. Some helper applications are launched by default but are completely tailorable by the user.

Images can be displayed in-line with text. Not only does Mosaic provide an easy-to-use, seamless interface for distributed systems, UNIX, Macintosh and Windows versions are also available.

In August 1993, the Central Node put up a WWW server and the PDS Home Page became available. Since then, six discipline nodes and five subnodes have put up WWW servers, all with links to and from the PDS Home Page.

Detailed descriptions of the PDS, the Central Node, six of the discipline nodes and five subnodes, and how to access data from these nodes is available from the following URLs:

- PDS Home Page
  <http://stardust.jpl.nasa.gov/pds_home.html>
- Central Node Home Page
  <http://stardust.jpl.nasa.gov/pds-cn- homepage.html>
- Atmospheres Home Page
  <http://miranda.colorado.edu:1234/pds/atmos_home.html>
- Geosciences Home Page
  <http://wwwpds.wustl.edu/>
- Geophysics Subnode
  <http://wwwpds.wustl.edu/geophys/>
- Infrared Imaging Subnode
  <http://esther.la.asu.edu/asu_tes>
- Microwave Subnode
  <http://delcano.mit.edu/>
- Spectroscopy Subnode
  <http://www.planetary.brown.edu/pds/>
- Imaging Home Page
  <http://cdwings.jpl.nasa.gov/pds>/
- Planetary Plasma Interactions Home Page
  <http://www.igpp.ucla.edu/scc/pdsppi/Welcome.html>
- Outer Planets Subnode:
  <http://www.physics.uiowa.edu/pds/>
- Rings Home Page
  <http://ringside.arc.nasa.gov/>
- Small Bodies Home Page
  <http://pdssbn.astro.umd.edu/home.html>

Together, these servers provide WWW users with the following services:

- Planetary Science Data Dictionary, Data Preparation Workbook, and PDS Standards Reference documents
- catalog submission templates and data label examples
- planetary data set and detailed-level catalogs
- bibliographies and documentation
- home and other institution links
- planetary image browsers
- in-review data

The PDS has not yet committed to using the WWW exclusively for distributing its services. However, the WWW pages now in place provide a uniform and seamless umbrella to the online catalog and planetary data analysis systems available from the PDS. The PDS Home Page is registered on the top-level WWW pages, which organize servers by country, server type and other categories. It can also be found within NASA's and the National Space Science Data Center's WWW pages, the NASA Online Resources Guide, as well as JPL's WWW pages.

## Technology transfer

The Data Archival and Retrieval Enhancement (DARE) Project sponsored by the Defense Nuclear Agency (DNA), has leveraged itself upon PDS standards. To describe DNA's data holdings, DARE adopted the PDS label standard (renamed the Portable Data Specification) as the foundation for its archive, search and retrieval system. Labels describing data products were then indexed using a suite of PERL scripts, WAIS software, and HTTP server software to provide both full-text and a keyword-value interface to both the information contained within the labels, and to the data described by those labels.

Because the DARE software was based upon PDS labels and fully configurable, the software was easily transferable back to PDS. The PDS and its discipline nodes are in the process of testing a new, hypertext implementation of the PDS Catalog. It is not intended to replace the current database, but to be an interface built from it. Metadata stored in the database are retrieved as PDS labels. These labels are then accessed by the DARE software to provide a hypertext environment for browsing the information contained within those labels. If approved, the system could be expanded to link metadata to data across PDS's distributed system.

## The future

The PDS is now in a position to achieve the dream it set out to achieve nine years ago. It is on the brink of finally pulling together all of its standards, databases, and archive-quality data sets, linking the metadata to the data, and providing the "best data to the most people." And doing it online.

For more information contact the author at: 818-306-6478; <abernath@stardust.jpl.nasa.gov> or access <http://stardust.jpl.nasa.gov>. ■

# The SPICE System: A Brief Overview


### Chuck Acton, NAIF Task Manager, Jet Propulsion Labortory


The Navigation Ancillary Information Facility (NAIF), acting under the directions of NASA's Office of Space Science, has built a data system--named SPICE--to assist scientists in planning and interpreting scientific observations from space borne-instruments. The principal objective of this information system is that it will provide geometric and much other ancillary information needed to recover the full value of science instrument data, and that it will facilitate correlation of individual instrument data sets with data from other instruments on the same or other spacecraft.

The primary SPICE data sets, called "kernels," contain-in a practical sense-the fundamental set of ancillary information of potential interest to scientists. SPICE kernels are composed of information which has been structured and formatted, without loss of information, for easy access and correct use by the science community. SPICE kernels are produced by the most knowledgeable sources of such information, usually located at a mission operations center. They must include or be accompanied by metadata--consistent with flight project data system standards--that provide pedigree and other descriptive information needed by prospective users.

SPICE kernel contents are summarized below:

- S spacecraft ephemeris, or more generally, location of an observer, given as a function of time.
- P planet, satellite, comet, or asteroid ephemerides, or more generally, location of a target body, given as a function of time.

The ephemeris data for spacecraft and target bodies are normally combined in a single file called the SPICE SPK file. (But either target ephemerides alone or a spacecraft ephemeris alone can be held in an SPK file; it is not necessary that both types be present.)

The P kernel also logically includes certain physical, dynamical and cartographic constants for target bodies, such as size and shape specifications, and orientation of the spin axis and prime meridian. These target body physical and cartographic constants are found in the SPICE PCK file.

- I instrument description kernel, containing descriptive and operational data peculiar to a particular scientific instrument, such as mounting alignment, internal timing relative to the spacecraft clock, and field-of-view model parameters. This instrument information is contained in the SPICE IK file.
- C pointing kernel, containing a transformation traditionally called the C-matrix that provides time-tagged pointing (orientation) angles for a spacecraft structure upon which science instruments are mounted. Attitude data are contained in the SPICE CK file.
- E events kernel, the principal contents of which are derived from the integrated sequence of events used to produce actual spacecraft commands. Events data are contained in the SPICE EK file set. (There are three components to the EK).

Several miscellaneous kernel files—spacecraft clock (SPICE SCLK file) and leapseconds (SPICE LSK file)—are also part of SPICE; these are used in converting time tags between various time measurement systems.

The SPICE system includes portable FORTRAN subroutines needed to read the kernel files and calculate most common observation geometry parameters. Users integrate these SPICE "Toolkit" subroutines into their own application programs to compute observation geometry parameters and related information where and as needed.

NAIF has designed the kernel file and software Toolkit architectures with portability and multimission application as principal goals. In addition, because extensive software documentation and examples are provided with the Toolkit, with a reasonable learning effort the software can be confidently used by the full spectrum of the NASA-supported space science community.

A flight project's mission operations center will concentrate on producing, cataloging and distributing complete and accurate kernels on a timely basis. Kernel updates will be made promptly if/as improved data sources become available.

Users may order those kernels of interest-using these at their home sites to compute needed geometric and related ancillary information. Users may update some kernels and produce their own versions of other kernels to support their own analyses or to provide their colleagues with any improvements in ancillary information resulting from their work.

Each flight project will deliver copies of all SPICE kernels and Toolkit software to the appropriate permanent archive facility, assuring ready availability of this data for future users. User-produced kernels may also be similarly archived.

Because ephemerides for most solar system target bodies are generally available, SPICE is frequently used for planning observations. In this case the observer could be a terrestrial telescope, a user-provided instrument location or a "predict" spacecraft ephemeris produced by NAIF or a mission design organization. In some cases "predict" versions of other

SPICE kernels are also made to help simulate a full data processing system. With this flexibility scientists may use SPICE throughout the experiment life cycle—from mission planning to detailed observation design to instrument data analysis and finally to correlation of results with those from other sources.

The core set of SPICE components is in place. Extension and adaptation of this core system to encompass broader functionality and to meet specific needs of new projects will be an ongoing endeavor. This work will include provision of some broadly useful application programs and development of additional kernel types.

The SPICE system is or soon will be used on numerous national and international space missions. While the principle use is in the planetary science discipline, astrophysics, space physics and even earth science projects are also using this technology. Limited data from some older missions such as Voyager, Viking and Pioneer have been "restored" into SPICE format.

In addition to providing SPICE technology to NASA and international space missions the NAIF Group serves as the Ancillary Data Node of NASA's Planetary Data System. In this role NAIF provides a permanent archive, and distribution and consultation functions for planetary project ancillary data sets.

SPICE files and NAIF Toolkit software may be requested by contacting the NAIF Group located in the Navigation Systems Section of Caltech's Jet Propulsion Laboratory in Pasadena California. Orders are filled as resources permit, with priority given to scientists doing data analysis directly supported by NASA's Office of Space Science.

For more information contact the author at 818-354-3869; cacton@naif.jpl.nasa.gov. ■

# New Software Provides Orbital Information

**_Nicole Rappaport, Cassini Radio Science Investigation Scientist, Jet Propulsion Laboratory_**

With its 12 instruments, Cassini is a complex spacecraft. Because of the long duration of the mission (the orbital tour around Saturn will last four years) and because of the cost-constrained environment, it is vital to design a spacecraft and ground system that are both robust and easy to operate. Cassini scientists take an active part in this enterprise. They came up with the concept of the BASIC mission, 98% of which is accomplished with repetitive sequences, the so-called modules and templates. To validate the BASIC mission concept, scientists have built sequences of five Titan flybys, four icy satellite flybys, and one Saturn flyby. Building sequences requires orbital information, which is what motivated writing the program ORBIT.

ORBIT provides orbital information relative to any celestial body in the solar system or any spacecraft. This program is written in standard FORTRAN 77. It runs within the Navigation and Ancillary Information Facility (NAIF) SPICE environment, making maximum use of subroutines from the NAIF Toolkit (SPICELIB) while the ephemeris database is provided by SPICE kernels. The program mainly consists of calls to SPICELIB subroutines, making it easy to read, easy to use, and increasing the confidence that it is right (the program was checked by comparisons with results published by the Cassini Mission Design Team).

ORBIT computes, for a specified series of evenly spaced times, a set of geometric quantities. Currently, the following quantities can be requested:

- position of a ‘’target,’’ as seen by an ‘’observer,’’ given in rectangular coordinates. The target is typically a planet or satellite, and the observer is typically a spacecraft.
- range, sub-latitude and sub-longitude of an observer as seen from a target. Rectangular coordinates of a vector, as seen by an observer.
- angular information: subsolar longitude, subsolar latitude, hour angle and phase

The rectangular and latitudinal coordinates are relative to any inertial reference frame supported by the SPICELIB subroutine CHGIRF or to a body-fixed reference frame, or to a planetocentric solar ecliptic reference frame. Except in the latter case, the time derivatives of the coordinates are also computed. The angular information is relative to a body-fixed reference frame, except for the phase that is reference frame independent.

ORBIT uses a simple configuration file to automatically load the SPICE kernels and an input file to specify the input parameters. Two types of output files can be obtained in the latest version. An example of one type is shown below (see figures).

Rectangular coordinates of vector SATURN to CASSINI, as seen from SATURN. Reference frame is J2000, with origin at SATURN. Aberration correction is NONE.

| | x(km)<br>dx/dt (km/sec) | y(km)<br>dy/dt (km/sec) | z(km)<br>dz/dt (km/sec) |
|---|---|---|---|
| 2007 OCT 26, 13:07:02 | -1.160277D+06 | 5.203024D+05 | 7.160651D+04 |
| | -4.570175D+00 | -5.232718D-01 | 2.785621D+00 |
| 2007 OCT 26, 13:07:03 | -1.160281D+06 | 5.203019D+05 | 7.160929D+04 |
| | -4.570142D+00 | -5.232990D-01 | 2.785615D+00 |

Figure 1. The content of the output file L_STAT2CAS_J2000

Latitudinal coordinates of vector SATURN to TITAN, as seen from SATURN. Reference frame is BODFIX with origin at SATURN. Aberration correction is NONE.

| | r(km)<br>dr/dt (km/sec) | lon(deg)<br>dlon/dt(d/sec) | lat(km)<br>dlat/dt (d/sec) |
|---|---|---|---|
| 2007 OCT 26, 13:07:02 | 1.256881D+06 | 6.730582D+01 | 2.198038D-01 |
| | 1.525615D-03 | 9.137349D-03 | -1.130978D-06 |
| 2007 OCT 26, 13:07:03 | 1.256881D+06 | 6.731495D+01 | 2.198026D-01 |
| | 1.524926D-03 | 9.137349D-03 | -1.130982D-06 |

Figure 2. The content of the output file L_STAT2TIT_BODFIXSAT

ORBIT was written with the intent of being a robust, general and user-friendly program. It does not contain exotic features and it will not be wowed by the computer science community. But it is hoped that the planetary science community will find ORBIT useful when orbital/geometrical information relative to any spacecraft or planetary body is needed. As for Cassini, ORBIT will be useful for the tour evaluation and planning observations.

For further details contact the author at: 818-354-8211. ■

# *Astrophysics Data Program Changes Proposal Procedures*


### *Guenter Riegler, NASA Hqs. and Jim Schombert, JPL/NASA Hqs.*


NASA Research Announcement 94-OSS-17, The Astrophysics Data Program , was released October 25, 1994. Proposals are due January 25, 1995. A scientific peer review committee will evaluate the proposals with the goal of announcing selections by April 1, 1995. During the 1995 proposal cycle, two types of proposals will be considered. This is a change from previous funding cycles that considered three types of proposals.

Type 1 proposals are those whose main focus is the analysis and interpretation of data from space astrophysics missions. Type 2 proposals may include the writing of algorithms for analyzing data, planning space-based astronomical observations, correlating or displaying space-based astronomical data; deconvolving sources in crowded fields, absolute radiance calibration techniques, statistically modeling the appearance of the sky in specific wavelength regions, providing tools for the NASA/Infrared Processing and Analysis Center Extragalactic Database; improving or adding reduction or analysis packages to any of the Astrophysics Science and Data Centers or to Astronomical Data Reduction and Analysis Systems; or other similar software activities. In addition, Type 2 proposals may include research to improve access to and management of space-based astronomical data.

A more significant change to the program concerns the peer review of proposals. In the past, Type 1 proposals were considered in competition only with each other for funding; similarly for Type 2 and Type 3. This new cycle will put all proposals, regardless of type, into the same competitive base. This new procedure will ensure that all proposals share and are judged on the common goal of improving the scientific output from NASA astrophysics mission data.

Participation in this program is open to all categories of organizations, domestic or foreign, including educational institutions, profit and nonprofit organizations, NASA centers, and other government agencies.

The last day to submit proposals is January 25, 1995. All forms are available through anonymous file transfer protocol from Internet host ftp.astrophysics.hq.nasa.gov. ASCII, Postscript, and Microsoft Word files for all appendices and required forms are in the directory /pub/NRAs/ADP/94-OSS-17. In addition, a file named README resides in this directory and gives detailed instructions on obtaining the necessary files electronically. ■

# The New Astrophysics Data System

**Guenther Eichhorn, Smithsonian Astrophysical Observatory**

The Astrophysics Data System (ADS) has been restructured. At NASA's request, ADS has been reduced in scope and budget relative to previous ADS activities. The main emphasis of the restructured ADS Project will be the operation and development of the ADS Abstract Service. The data assets already created by the ADS Project will be consolidated so that they will be administered within the restructured project and will continue to be available.

The re-structuring of ADS is necessitated by continued budgetary pressures within NASA. The availability of alternative distributed data access mechanisms allows the ADS Project to phase out the proprietary software it was using in favor of World Wide Web-based protocols, while still maintaining some of the infrastructure that is a key component of this distributed information system. The objective is to provide complete support for the existing ADS Abstract Service and to maintain access to as much of the existing ADS data assets as possible within the resource constraints. The ''classical'' ADS project will continue to operate for as long as possible during this transition to Web services. However, high levels of user or node support will not be provided due to reduced resources.

## Information and abstract service

The ADS Abstract Service has been successful in providing the astronomy researcher the capability to search the astronomical literature. It currently provides access to over 160,000 astronomical abstracts with a sophisticated search engine. The emphasis of ADS in the coming year will be to utilize technologies like the Web to provide access to a wide variety of users through public domain client software. The abstract database will be expanded to cover more topics, e.g., instrumentation and space physics. Under consideration is enhancing the functionality of the Abstract Service to include a citation index that will allow you to browse through the abstracts of references associated with the current abstract.

Development work will include cooperation with the publishers of astronomical literature to provide access to the original author abstracts. Providing access to the full articles in bitmapped form is also being worked. As a first step in this direction, the Astrophysical Journal Letters and possibly some of the astrophysical journals will be brought online. User response to having full journal articles available and linked with the abstracts will be evaluated. If it proves to be a valuable service, ADS will work with publishers to digitize more of the old literature and to see whether access to electronic forms of new articles can be provided.

Recently it has become possible to "publish" electronically, data tables from a journal article. Work on linking these data tables to the abstracts of the articles has begun. ADS is making use of the online data currently available through the Centre de Donnes astronomiques de Strasbourg (CDS). The objective is to provide access to these data from the abstracts that refer to them.

The efforts described above will extend the scope of the abstract service and expand it into a wide ranging digital library service with greatly enhanced utility for the astronomical community.

## Catalogs and archives

Another part of the ADS data access effort is to provide access through the Web to data that are available through the ADS Project. Currently, a prototype Web Catalog Access Tool is available. This tool provides access to catalogs at the Smithsonian Astrophysical Observatory (SAO), the Center for Astrophysics and Space Astronomy (University of Colorado), and the University of Minnesota. For some catalogs, like the plate scan data at the University of Minnesota, ADS is the primary means of data access. It is therefore important that this catalog access be maintained.

The central location service provided by ADS helps to deal with the general problem of how the user community can know about the existence of valuable data. ADS plans to continue to provide this important (and unique) function through its Web catalog server at <http://adscat.harvard.edu/catalog_service.html>. Data holders are encouraged to make their catalogs available on the Web. ADS has a set of programs that provides Web access to catalog data. It allows you to select data from any catalog in the database. It works as it is with several databases and can easily be adapted to other databases. Instructions on how to get and install this catalog server are at <http://adsdoc.harvard.edu/install.html>.

Similarly, ADS is working on a prototype Web server for archival data. The initial effort will provide access to the Einstein Observatory data set maintained at SAO. ADS plans to work with current ADS data providers to help in the transition from ADS servers using proprietary protocols to servers based on Web protocols. ADS will also include links within the ADS Web Services Home Page to other sources of astronomical data so that there will be a single starting point for finding these resources. The ADS Web Services Home Page can be found at <http://adswww.harvard.edu/ads_services.html>

For further details contact the ADS Project at <ads@cfa.harvard.edu>. ■

# Oceanography Archive Distributes Ocean & Atmosphere Collection

**Chris Finch, Jet Propulsion Laboratory**

The Physical Oceanography Distributed Active Archive Center (PO.DAAC) announces the availability of Tropical Ocean and Global Atmosphere (TOGA) data sets on CD-ROM. The TOGA CD-ROM set contains 15 data sets that, together, meet most of the TOGA project data requirements.

The highest priority requirement for TOGA is a consistent high-quality, decade-long series of data describing the relevant components of the climate system. (TOGA International Implementation Plan).

The purpose of the TOGA CD-ROM set is to make selected TOGA data sets easily available to a variety of users. The users will be predominantly ocean scientists, but will also include scientists from the meteorological and climatological communities.

A primary goal of the JPL PO.DAAC is to serve the needs of the oceanographic, geophysical and interdisciplinary science communities that require physical information about the oceans. By producing and distributing such a product, the PO.DAAC will be providing data of interest to its primary user community.

## Background

TOGA, part of the World Climate Research Program (WCRP), is a 10-year project (1985-1994) to study the coupled ocean-atmosphere system. The scientific objectives of TOGA, as stated in the TOGA International Implementation Plan are:

- to gain a description of the tropical oceans and the global atmosphere as a time-dependent system, in order to determine the extent to which this system is predictable on time scales of months to years, and to understand the mechanisms and processes underlying its predictability
- to study the feasibility of modeling the coupled ocean-atmosphere system for the purpose of predicting its variations on time scales of months to years
- to provide the scientific background for designing an observing and data transmission system for operational prediction if this capability is demonstrated by coupled ocean-atmosphere models

To achieve these goals, TOGA is measuring atmospheric and oceanographic variables for the 10-year period and performing modeling studies of the coupled ocean-atmosphere system aimed at prediction of the system.

The TOGA CD-ROM project is an effort to distribute both in situ and model data from the WCRP TOGA project. In 1990, the NASA Ocean Data System (NODS, the former name of the PO.DAAC) undertook the TOGA CD-ROM Pilot Project. The International TOGA Project Office (ITPO) arranged for the transfer of nine data sets containing observations and model results to NODS at JPL, which were then assembled onto a CD-ROM. The final result, TOGA CD-ROM Description, Halpern, et al, (JPL Publication 90-43) was distributed to the TOGA research community. This is referred to as the Pilot CD-ROM.

In April 1991, a TOGA CD-ROM Review was held at JPL. Information gathered by the ITPO from a questionnaire sent out with the data contained many favorable comments and constructive criticisms. As a result of this meeting, it was decided that the JPL PO.DAAC should propose to the ITPO to publish a TOGA CD-ROM set that covers the entire TOGA project period from 1985 to 1994. The following guidelines for the development of the TOGA CD-ROM were established:

- all data sets on the Pilot CD-ROM would be included, plus additional data sets and additional parameters to be provided by the European Centre for Medium-range Weather Forecasts (ECMWF)
- ASCII and gridded binary code would remain the only data formats used
- additional software should be developed, preferably in the ‘‘C’’ language, for enhanced data manipulation and visualization
- at least part of the software should be portable to as many hardware configurations as possible

## TOGA CD-ROM package

The TOGA CD-ROM package consists of a set of six CD-ROMs containing in situ and numerical model data for the years 1985—1990, formatted according to the ISO-9660 standard, one CD-ROM containing application software for visualizing and extracting data on a PC-compatible system, a document that describes the dataa and software, and two documents describing the ECMWF model. Macintosh-compatible software of limited functionality (data extraction only) is also included on the software CD-ROM.

TOGA software PC-Compatible TOGA CD-ROM interface software—The TOGA CD-ROM Interface Software (see figures) is designed to locate, view, and extract data of interest to the investigator based on time, location, parameter, or data set. The graphical user interface allows you to browse through the data contained on a CD-ROM and select files for viewing. You can also browse through lists of data files created by either searching the CD for data files matching specific criteria or by selecting the files manually. The menus may be traversed with the mouse or the keyboard using the key with the underscored letters in the menus.

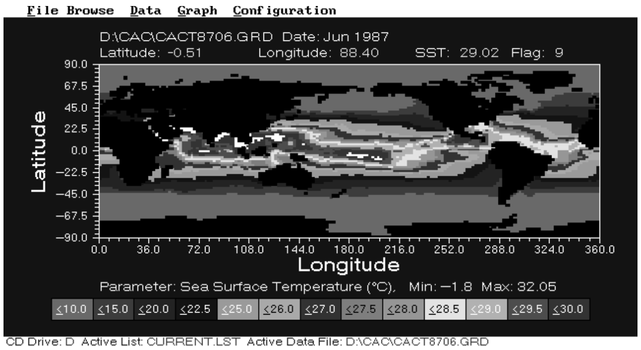



Figure 1. TOGA CD-ROM Interface Software CAC sea surface temperature graphic display.

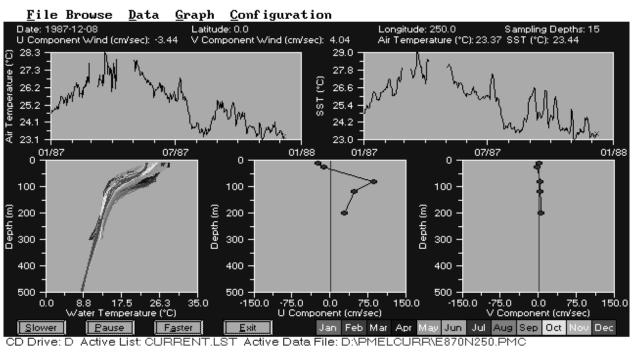



Figure 2. TOGA CD-ROM Interface SoftwarePMELCURR moored current meter graphic display

Macintosh TOGAextract software—The TOGAextract program is designed to locate and extract data of interest to the investigator based on time, location, parameter, or data set. TOGAextract has no facility with which to view images of the data, but can output “raw” 8-biit images of the gridded data sets. ASCII output can be obtained from all data sets.

Other supplied software—The following other software packages arre supplied with the TOGA CD-ROM: OPC-PLOT, oceanographic charting software for the world’s oceans, produced by USGS Minerals Management Service; PCSHOW, software for viewing images on the PC, developed by NCSA; IMDISP, more software for image display on the PC, developed by the JPL Planetary Data System; ATLAST, PC software to plot and examine oceanographic section data, developed by Peter Rhines; NCSA Image for image display on the Macintosh, developed by NCSA; Imagic, also for image display on the Macintosh, developed by Charles Norris and William Emery; and OceanAtlas, a Macintosh version of ATLAST, developed by John Osbourne and James Swift. Documentation files are included with the software, when available, which more fully document the software.

For more information on the TOGA data product contact the JPL PO.DAAC User Services Office at: 818-354-9890 or <podaac@shrimp.jpl.nasa.gov>

## References


1. Collins, D.J., 1991: Physical Oceanography Version 0 Distributed Active Archive Center Science Support Plan. JPL Internal Document D-9247, 43 pp.
2. Finch, C.J., 1994: Physical Oceanography Distributed Active Archive Center TOGA CD-ROM Users’ Guide, JPL Internal Document D-11538, 126 pp.
3. Halpern, D., H. Ashby, C. Finch, E. Smith, and J. Robles, 1990: TOGA CD-ROM Description. JPL Publication 90-43. 43 pp.
4. ITPO, 1991: Report of TOGA CD-ROM Project Planning Meeting, International TOGA Project Office, 11 pp.
5. ITPO, 1992: TOGA International Implementation Plan, Fourth Edition, International TOGA Project Office, 73 pp. ■

# NSI Supports Dante II Robot Experiment in Alaska

**Pat Kaspar, Ames Research Center**

The NASA Science Internet (NSI) participated in the recent Dante II robotic exploration of Alaska's Mt. Spurr Volcano in July and August 1994, which tested hardware and techniques for future automated exploration of the moon and Mars. Network connectivity made possible transmission of video and telemetry to telepresence researchers at Ames Research Center, live demonstrations at the National Air & Space Museum in Washington, D.C., and daily status reports over the Internet.

***"NSI connectivity was crucial to the success of the Dante II mission to Mt. Spurr in two areas," said Butler Hine, Intelligent Mechanisms group leader in the Information Sciences Division at Ames Research Center. "One was a highly reliable command/telemetry channel for remote science operations of the robot from Ames. The other was the connectivity used to provide the public outreach program at the National Air and Space Museum in Washington. Neither of these components to the mission would have been successful without the support of NSI. During the mission, we had a World Wide Web page set up to reflect the mission telemetry and data in real time. This Web page recorded over 16,000 connections per day during the mission, with over 100,000 connections total during the two weeks of the mission. This type of outreach depended on the NSI connection to Anchorage."***

The Dante II robot, built at the Carnegie Mellon University's Robotics Institute in Pittsburgh, carried video cameras, sensors and communications equipment. The robot was controlled via satellite and over the Internet, enabling operators to experiment with virtual reality and telepresence control to explore environments too dangerous for humans. Four of the robot's eight video cameras could be used at a time for stereo viewing, and four control modes allowed operators to select from full autonomous control to individual control of each of the robot's eight legs. Terrain contour maps were generated by a Sun Microsystems Sparc Station processor from data received from an onboard laser rangefinder. These maps were used by human controllers as well as by the robot for navigation. Data and images were sent from Dante II to the volcano's rim through its tether, which contained a 1000-volt power line and four redundant twisted pairs of Ethernet wires. Telemetry was accomplished from the satellite relay on the volcano rim to the control center in Anchorage via the Hughes SBS-5 Ku-band satellite. From Anchorage, a high-bandwidth T1 connection reached Ames Research Center over fiber-optic land lines. Another link from Anchorage reached Goddard Space Flight Center and the National Air & Space Museum via Ka-band on the NASA Advanced Communications Technology Satellite. (ACTS is an experimental spacecraft that provides "on-demand," high-bandwidth data, voice and video service, and is able to reach locations that are not presently served by fiber optic cable.) Video of the robot's explorations were broadcast from Goddard over NASA Select television.

Dante II built upon previous experience gained by Dante I in 1992-1993 at Mt. Erebus, Antarctica, and incorporated numerous technological advances. The communications infrastructure that controlled Dante II enabled telepresence for human explorers and scientists by combining use of the Internet, new satellite technology, autonomous controls and virtual reality. This infrastructure is similar to what scientists expect will be used to demonstrate very remote viewing and teleoperations under extreme conditions and in remote locations such as on the moon, the space shuttle and the space station. ■