JOINT
U.S. GEOLOGICAL SURVEY/JET PROPULSION LABORATORY
SCIENTIFIC VISUALIZATION WORKSHOP,
NORFOLK, VIRGINIA,
MAY 18-19, 1992:
PROGRAM AND ABSTRACTS

Compiled by Richard A. MacDonald, Gerry Lebing, and
R. Michael Hathaway

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DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

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FOREWORD

Visualization is both a method of computing and a presentation discipline. It is revolutionizing virtually every field of science and engineering. It enables researchers to observe their simulations and computations. Scientific visualization is a combination of computer graphics, image processing, computer vision, computer-aided design, signal processing, and user interface studies. Visualization offers a method for validating models and for discerning patterns in voluminous data sets. Visualization also allows the scientist to interact with data to enhance simulation of earth-science processes. Thus, the goals of visualization are to provide new scientific insight through visual methods and to provide an effective way to present results -- to colleagues and to the public.

The Joint United States Geological Survey and Jet Propulsion Laboratory Scientific Visualization Workshop is being held as a forum to present techniques for viewing earth science data. The compilation of papers presented at the conference describe work done in the field of scientific visualization and share experiences with some of the many hardware and software tools that have become available for use in this field.

Richard A. MacDonald

Richard A. MacDonald
Workshop Coordinator

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Joint U. S. Geological Survey/Jet Propulsion Laboratory Scientific Visualization Workshop

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Norfolk, Virginia
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Posters for
Joint U. S. Geological Survey/Jet Propulsion Laboratory
Scientific Visualization Workshop

DIMENSION -- A Computer Program that Computes the Fractal Dimension of Lines or Points on a Flat Planar Surface

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Barton, Christopher C., U.S. Geological Survey, Geologic Division, MS 940, Denver Federal Center, Denver, CO 80225;
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DIMENSION is a computer program that computes the fractal dimension of a data set that consists of lines or points in a plane. The fractal dimension is defined by selecting any one of six algorithms incorporated into the program. These algorithms are the Box Method, the Box-Rotate Method, the Box-Flex Method, the Block-Density Method, the Perimeter-Area Method, and the Hausdorff Method. For each of these methods, DIMENSION allows the user to define interactively the range of scales over which the fractal dimension is determined and to create screen graphics and presentation-quality plots of the fractal analysis results.

There are two versions of the DIMENSION program. The first is written in the Turbo Pascal 4.0 programming language for use on any DOS-compatible microcomputer. This version of the software includes Hewlett-Packard Graphics Language (HPGL) calls which enable the user to create presentation-quality plots on any HPGL-compatible plotter. The second version of the software is written in the C programming language and incorporates SunView and X Windows graphics calls for use on Sun and Data General workstations.

Macintosh Multimedia Educational System Incorporates Terrain Fly-by Rendered on PIXAR Image Computer

Coats, Gregory, U.S. Geological Survey, National Mapping Division, 586 National Center, Reston, VA 22092;
Powell, Mary E., U.S. Geological Survey, Information Systems Division, 804 National Center, Reston, VA 22092

Researchers at the U.S. Geological Survey (USGS) are developing a multimedia system for elementary school students who are using minimally-configured Apple Macintosh computers. The Macintosh is used in most schools and provides multimedia capability; therefore it is an appropriate platform for the purpose of our system.

Part of this multimedia system will show an animation sequence of a terrain fly-by in a perspective view. However, USGS developers require a sophisticated hardware platform such as a Sun Microsystems workstation that controls a PIXAR Image Computer for this type of image rendering process. Using this platform, hundreds of fly-by perspective views of a Landsat scene registered to and draped over a digital elevation model can be rendered in a matter of hours. These rendered images can then be ported to a Macintosh and selectively used for an animation sequence.

It is the marriage of the Macintosh and Sun/PIXAR hardware platforms that enables us to meet the requirements for developing this multimedia system. Preliminary results of this development effort suggest that this combined platform approach provides excellent results for producing presentation-quality animations.

Visualization of Geologic Hazards in the San Francisco Bay Area

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Providing information to mitigate the impacts of earth science hazards, such as earthquakes and landslides, is a vital part of the U.S. Geological Survey's mission. Earthquakes and landslides are significant hazards in the San Francisco Bay area of California; in 1989 the Loma Prieta earthquake caused 62 deaths and over $6 billion dollars in property damage.

To study the effects of these hazards over a wide region, a digital data base of the bay area was compiled in which a combination of multispectral satellite bands, selected to emphasize areas prone to landslides, was combined with a terrain model created at the same resolution. Although features like the San Andreas fault are not separately identifiable in either the x-y satellite images or the z-only terrain model, the integration of these two data sets with terrain rendering techniques creates a perspective view in which these features are easily visualized.

The Survey's Geographic Information Systems (GIS) Research Laboratory scientific visualization workstation in Reston, Virginia, includes a Pixar Image Computer that was used to render several thousand perspective views of the bay area. Working cooperatively, scientific visualization specialists in the Geographic Information Systems Research Laboratory and the Geologic Division of the Survey created a video of the San Francisco Bay area that travels down the San Andreas fault.

Multiscale Visualization of Spatial Processes

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Montagne, Nalan, Computer Sciences Corporation

Mapping environmental data requires the characterization and understanding of spatial patterns and processes at multiple scales. As part of the U.S. Global Change Research Program, a C program was developed that simulates several spatial processes for real-time visualization to compare idealized data with empirical measurements. The program opens a window on an X Windows workstation and prompts the user for the type of simulation desired, as well as for the various process parameters. The system is designed so that a number of possible spatial processes can be added in the future, but at the moment the program simulates three processes, producing values of z on a 256 X 256 lattice:

- a simple negative-exponential process $z \propto \varepsilon^{-(x-c)2}$, where the values of a cell x decline with its distance from some point c (usually the center of the lattice).
- a random gaussian process $z \sim N(\mu,\sigma)$, where cell values are normally distributed with mean μ and variance σ^2.
- a complex random walk process, in which the value of z is the number of times that an orthogonal random walk has visited a cell.

The program is useful in the simulation of lattice processes for the analysis of raster data so that resulting patterns and statistics (such as autocorrelation and multifractal dimension) can be compared with those generated by simple, random, or complex processes. The files generated by this simulation are used to compare these processes with multiscale analytical results from the analysis of digital elevation, satellite, and gridded climate data. This research will be of particular interest to scientists and programmers wishing to use the Distributed Information System II workstation for scientific visualization.

An Experiment in Desktop Video Production for Earth Science Applications

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The U.S. Geological Survey (USGS) is currently assessing hardware and software tools for computer-based analysis and presentation of scientific data. At the USGS, scientists are experimenting with new computer- and video-based techniques for analyzing large quantities of data that are collected as part of the research process. In many cases, the enormous amounts of information, inherent to three-dimensional data, and the time dependencies of the data make it difficult to effectively analyze the information using even the most sophisticated two-dimensional graphics software. Many earth science processes, such as the simulation of earthquakes and volcanic eruptions, are best depicted using computer-based animation and three-dimensional visualization techniques.

Large-screen monitors and projection systems are frequently used for displaying computer-generated animations. A computer can be used with one of these display devices to show the animations; however, it can be very costly to either bring a computer or rent one for a presentation. Videotape is a potentially viable alternative because it is a portable media, videotape recorders are readily available, and a computer is not needed to display the animation. Videotapes can also be a cost effective distribution media. For example, a researcher could produce a limited number of copies of a videotape and send them to his colleagues to review the results of research projects.

There are several major goals in assessing video technology as a presentation and analysis tool. First, it must be determined if there is a need for this technology. One critical factor is that it is expensive to have video presentations produced by private organizations. Second, if it is determined that scientists can develop their own video products, then it will be possible to set up desktop video production systems at USGS offices throughout the country. The major evaluation criteria to determine this are ease of product development, time to produce product, training requirements, and cost considerations.

This paper describes the computer system used to create the animations (an Apple Macintosh IIfx), video hardware used to record the animations, and video editing equipment used to produce the final videotape for either a presentation or distribution. Methods used to import earth science data for use in the animated sequences are also discussed.

Preliminary results of the study on desktop video production indicate that the hardware and software are very expensive. The system used in this assessment cost more than $30,000, and more could have been spent especially on the video equipment to produce a higher quality video. Information will be provided on the minimum that can be spent to produce an acceptable product and the costs involved in using a private organization to produce the video. Also, many of the software packages are difficult to learn partially because of the complexity and wide range of software features. In addition, many skills are required to produce quality video products. Creating the animations requires such skills as an extensive knowledge of computer hardware and interfacing video equipment to the computer and a thorough knowledge of the subject of the presentation. Producing the video requires such skills as knowledge of video equipment, graphic design, script writing, and editorial expertise.

An Interactive Scientific Data Visualization Environment Within the X Window System

Granger, Gary J., U.S. Geological Survey, Water Resources Division, 430 National Center, Reston, VA 22092;
Johnson, Margaret F., U.S. Geological Survey, Information Systems Division, 804 National Center, Reston, VA 22092

Visualization of scientific data often must be accomplished using several different plotting utilities and computer systems. Problems arise because of incompatibility of data and graphical formats and because excessive amounts of time and money are spent by scientists who must learn, operate, and maintain each of these varied utilities and systems. Also, general plotting tools are frequently not flexible enough to provide both simple visualization plots and report-quality figures meeting rigid publication standards. Scientists at the U.S. Geological Survey are solving these problems by developing a single, integrated, data-visualization tool: the Scientific, Interactive, and Extensible Visualization Environment (SIEVE) for UNIX-based workstations.

SIEVE provides a user-friendly, flexible, and portable environment within which a broad range of visualization-related functions can be performed. The X Window System and the Massachusetts Institute of Technology's Athena Widgets serve as the foundation for SIEVE's graphical user interface. Unidata's netCDF, a machine-independent, self-descriptive, direct-access data file format, allows SIEVE to display the structure and attributes of data files conveniently and efficiently within an X window. SIEVE's visualization graphics are based on the Graphical Kernel System (GKS) ANSI/ISO standard. Thus SIEVE can incorporate any GKS plotting routines, even specialized, user-defined routines, through FORTRAN and C-language interfaces provided within SIEVE. SIEVE uses XGKS, a Unidata-supported, public-domain implementation of GKS for the X Window System, to display plotting calls in an X window. The National Center for Atmospheric Research (NCAR) graphics library, which is based on GKS, supplies many of SIEVE's built-in plotting capabilities. For output, SIEVE supports the ANSI Computer Graphics Metafile (CGM) standard and the PostScript format, among others. The X Toolkit Intrinsics resource manager controls the attributes and plotting options within SIEVE; hence SIEVE can be adapted to the user's needs and desires from generation of "rough draft" plots to "publication quality" figures. SIEVE reduces dependence on specific software or hardware systems by focusing on portable, well-maintained, quality, public-domain components: machine-independent netCDF data files, the GKS and CGM standards, the X Window System standard, and the UNIX platform. All of the software components used by SIEVE are supported by public institutions. NetCDF, XGKS, and the Athena Widgets are available at no cost, while NCAR Graphics is available at nominal cost--institutional site licenses are available.

SIEVE, by means of data windows and pull-down menus, permits users to select various types of data from netCDF files, such as time-domain data, three-dimensional data, and map-coverage data. For visualization, various routines are available for creating general plots such as simple line graphs, contour plots, three-dimensional surface renderings, and gridded vector fields. Other routines can be more specialized, such as the routine which plots map boundaries derived from ARC/INFO, a Geographical Information System. Several plots can be combined in one plot window, and several plot and data windows can be viewed simultaneously. Hence immediate visual and numerical comparisons of data sets are possible. In addition, SIEVE can add and graphically edit labels, axes, fonts, legends, and other objects within the GKS window. SIEVE is being developed on a Sun SPARCstation and has been ported to the Data General AViiON series of workstations, as well.

Large Scale Three-Dimensional Image Rendering

Hall, Jeffrey R., Visualization and Earth Sciences Applications Group, Image Processing Applications and Development Section (384), Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099

In November 1990, a forty-two minute IMAX film entitled *Blue Planet* opened to the public worldwide. This film contains a one hundred second computer-generated animation of a flight and earthquake simulation along the San Andreas fault in California. This animation was produced by the Jet Propulsion Laboratory (JPL) under a technology development task sponsored by IMAX Corporation through an agreement with the National Aeronautics and Space Administration (NASA). This is a summary of work performed at JPL under this task.

The main technological development of this task was to enable three-dimensional perspective terrain rendering of very large digital images within a "short" period of time. A processing speedup of over twenty times was achieved through implementation of an algorithm which uses a pyramid structure for the image and elevation data. This animation required 727 megabytes of input data to create 43 gigabytes of digital output frames. Prototype interactive software was used for selecting the key frames of the flight path.

Among the extensive image processing steps performed in preparing the input data for rendering was the derivation of synthetic "true" color from false color infra-red images. The data used in this animation were obtained from three sources: an image mosaic of California constructed from Landsat Multispectral Scanner scenes, a Landsat Thematic Mapper scene of the San Francisco area, and U.S. Geological Survey Digital Elevation Model (DEM) data.

Technology developed for this task has since benefited NASA's Magellan Radar Mapping Project by enabling three-dimensional perspective science animations to be created from very large digital mosaics of the surface of Venus.

This talk will detail the image processing steps, the key frame selection and flight path design process, and final rendering. A videotape of the animation will be shown.

Visualization of Scientific Information on a Distributed Information System II Workstation

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McCulloch, David S., U.S. Geological Survey, Water Resources Division, 227 N. Bronough Street, Suite 3015, Tallahassee, FL 32301

A project, sponsored by the U.S. Geological Survey is underway in Florida to evaluate the potential of Distributed Information System II (DIS-II) workstations in the analysis of scientific information through visualization. Visualization of scientific information, as defined for this project, is characterized by the visual analysis of data and differs from other graphic techniques by presenting concrete multidimensional views of symbolic data. The project uses an AViiON 410 workstation with 16 megabytes of random access memory, one gigabyte of disk space, 24-bit color graphics, and a Z-buffer together with the DG/UX 4.32 operating system and standard suite of DIS-II software. A survey of the software industry identified only one vendor providing software with any scientific visualization capabilities for the DIS-II workstation. The visualization software was purchased and installed on the workstation in November 1991.

Results of early experiments on the workstation indicate that rendering functions, three-dimensional isovalue shells, and volume calculations, each of which are crucial to visualizing scientific information, are primitive or unavailable and thus limit use in true visualization applications. However, inadequacies in the present geographic information system's surface-modeling software provided the opportunity to use the visualization software in three-dimensional applications. Providing geographically referenced images for use with the geographic information system provided a two-dimensional application.

The first application was to visualize concentrations of individual water-quality constituents from selected wells penetrating the Floridan aquifer system in a multicounty area of northern Florida. The four components of this visualization, county boundaries, well features, constituent concentrations, and the top of the Floridan, were extracted from the geographic information system. The visualization software was then used to generate an image of the county boundaries, a three-dimensional surface of the top of the Floridan, the wells, and a three-dimensional flooded contour surface of constituent concentrations.

The second application provided a geographically referenced image of the land surface elevation of Florida to use as a background image. One-degree digital elevation model data were extracted from the geographic information system and processed in the visualization software to generate a two-dimensional flooded contour image of land surface elevation. This image was registered in the geographic information system and is used as a background image for hydrography and other coverages.

The third application was to visualize areas of potential artesian flow from the Floridan aquifer system in Florida. Potentiometric surface data and one-degree digital elevation model data were extracted from the geographic information system and processed using visualization software to generate a three-dimensional potentiometric surface and a three-dimensional land surface. Intersecting these two surfaces produced a third three-dimensional surface showing the artesian flow areas.

Results of these experiments indicate that the DIS-II workstation can be used in modest applications of scientific information visualization. More sophisticated software is needed to fully test the DIS-II workstation's visualization potential. Discussions to encourage visualization software vendors to convert software to the DIS-II workstation continue.

Diamond in the Rough: Enhancements to Piper Diagrams

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A Piper Diagram is one of the most common graphical techniques for interpretation of ground-water geochemical data. Percentages of major ions for one or more groups of data are plotted on the diagram. It effectively illustrates interpretations such as "waters in group A are different in quality than waters in group B" or "water type changes downgradient." Regions of the diagram representing groups of samples are delineated by eye, usually by drawing an envelope around most or all of the samples in each group. Interpretations would be improved by providing quantitative boundaries for a water type, measures of differences between water types, and significance tests for change in water type. Such numerical measures can then be illustrated on the diagram. Note that standard tests of significance are inappropriate for compositional data -- data whose elements sum to 100 percent. Using the additive logistic transformation, however, compositional data can be transformed into units amenable to statistical analysis. In previous uses of this technique, multivariate normality was assumed and parametric statistics performed on the transformed data. The requirement of multivariate normality is difficult to verify, casting doubt on the validity of test results. Non-parametric techniques are applied to transformed compositional data and the results re-expressed in original units on the Piper Diagram. Tests for differences in median water types are performed and confidence limits plotted on the diagram. Trend analyses are conducted to determine if trends in water type occur downgradient. Smoothing procedures are applied to impartially delineate regions on a Piper Diagram which depict homogeneous groups of data or to compare groups of data.

Data Fusion and Three-Dimensional Visualization: Demonstrations of Current and Future Technology

Hussey, Kevin J., Technical Group Supervisor, Visualization and Earth Science Applications Group, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099

The Jet Propulsion Laboratory (JPL) has been developing Surveyor, a three-dimensional data visualization system which runs in a heterogeneous distributed computing environment. Surveyor can be used by scientists and simulators to move around a three-dimensional "world" for the purpose of analyzing that world. The world can consist of a variety of three-dimensional data, such as satellite imagery combined with topography information. Surveyor provides not only three-dimensional rendering of data but also an inverse rendering capability, which can retrieve the original data values for selected areas in a three-dimensional rendered scene. This capability can be used as a user interface for the analysis of scientific data, such as geological data bases from desktop computers or across a network to allow use of more powerful machines.

The same group has created an animation which simulates a flight through the Monterey Bay environment using seven different geophysical data sets. *Monterey: The Bay* is the most technically sophisticated animation produced by JPL's visualization and earth science applications group to date by virtue of the number of data sets used and the manner in which they were combined. The animation begins over the Monterey Peninsula and "flies" westward above the Pacific Ocean to a distance 175 miles offshore and then drops below the ocean surface to show the large Monterey Bay canyon. The "flight" travels up the canyon to the mouth of the bay, where ocean currents are shown using a graphical model. The animation finishes with a sweeping tour above the bay. A video presentation of both a Surveyor demonstration and *Monterey: The Bay* will be given.

A Microcomputer-based Process for Producing Video of Time-dependent Scientific Data

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Rybicki, Nancy B., U.S. Geological Survey, Water Resources Division, 430 National Center, Reston, VA 22092

Presenting time-dependent scientific data in an easily understood manner is sometimes a difficult task. Often, meaningful interpretation of these data can be derived only by viewing a series of graphical images with minimal delay between successive images. This typically requires a system of computer hardware and software capable of displaying large amounts of graphical information rapidly. Unfortunately, such systems tend to be expensive. A microcomputer-based system maintained by the U.S. Geological Survey's computer graphics support center is being used by researchers as an efficient and cost-effective alternative.

By using graphic manipulation software, plots of scientific data stored in Computer Graphics Metafiles, a hardware-independent file structure, are transformed into images more suitable for presentation. This is done by enhancing image attributes such as colors, text fonts, and line thicknesses. Attribute editing takes place in batch mode so that sequential images are processed without human intervention. After they have been edited, images are displayed on a microcomputer monitor using an animation software package with playback-speed control, titling, and other visual-effect capabilities. A specialized circuit board in the microcomputer allows images displayed on the monitor to be routed to a videotape recorder where they are captured. The recorded video images are then combined with audio and live video to create readily understandable and intuitive presentations. Example animations, as well as a poster illustrating the animation process, will be presented.

The Use and Limitations of the Computer Graphics Metafile Standard for the Transport of Computer Generated Images

Lebing, Gerry, U.S. Geological Survey, Information Systems Division, 804 National Center, Reston, VA 22092

The Computer Graphics Metafile (CGM) is an American National Standards Institute and International Organization for Standards graphics standard that defines a hardware-independent structure for storing and transferring graphics information. The CGM standard includes four different graphics primitive elements (line, marker, text and filled area) and many attributes associated with them (color, line type, text font index, etc.). A complete implementation of the CGM standard consists of two interdependent units: the CGM generator and the CGM interpreter. The CGM generator is responsible for translating graphical information into a CGM file. This file is basically a list of CGM primitives and their associated attributes. The role of the CGM interpreter is to convert this list into an image with most of the graphical attributes of the original display.

The CGM standard was designed to facilitate the migration of computer graphics between software packages, but variations in its implementation can result in the loss of graphical attributes. Based on a study conducted by the U.S. Geological Survey (USGS), results show that many implementations of the CGM in use at the USGS do not preserve essential graphical information.

The Computer-aided Acquisition and Logistic Support (CALS) is an application profile that seeks to provide for the effective and unambiguous use of CGM by adding a set of specifications beyond the published CGM standard. In particular, CALS specifies the behavior of CGM generators and interpreters. A brief review of CALS is included in this paper.

Subsurface Geology of a Soviet Nuclear Test Site

Leith, William S., U.S. Geological Survey, Geologic Division, 928 National Center, Reston, VA 22092;
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Unger, John D., U.S. Geological Survey, Geologic Division, 922 National Center, Reston, VA 22092;
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To support seismological analyses of the seismic variability or regionalization of the Soviet's Balapan underground nuclear test site, we have constructed a preliminary three-dimensional model of the geology of that site. This model shows the lateral and depth variations of the principal geologic units at the site, as estimated by a combination of visible, surface geologic contacts, subsurface drill hole data, and the computed extrapolation of contacts away from "real" data points.

The model covers the depth range from the surface to a depth of -1000 meters (absolute elevation), for the area of 78.60° to 79.10° E., and 49.80° to 50.12° N. This area was defined by a coordinate-registered SPOT image mosaic of the site, which was used as a base map for digitizing surface data points.

The geologic data used to control the model surfaces come from a number of sources, including interpreted commercial satellite images and Soviet-published drill-hole and explosion data. For example, we have used subsurface geologic data published by the Soviets for the 1004 crater, the Yubiley coal basin and five other explosions at the site, in combination with our own remote mapping of the surface geologic features. As new data become available, they are entered into the computerized database, and new surfaces (i.e., geologic contacts) are calculated. This process was used, for example, to compare recently published Soviet data with our previously calculated model surfaces.

While the three-dimensional model is reproducible at any resolution, we are currently working at a resolution of 359 by 351 elements (horizontally) by 150 (vertically) -- exactly one-tenth of the resolution of the SPOT image mosaic. This results in a cube of data that approximates the geology at a 100-meter spacing horizontally and 10-meter spacing vertically. With the addition of more data, of course, both the resolution and the accuracy of the model will improve.

Using yield, seismic magnitude and depth information from Bocharov and Zelentsov, (1989, Atomic Energy, v. 67, no. 3, p. 210-214) and other sources for calibration, we have estimated the emplacement depths of 85 Balapan events. Using these depth estimates, the geologic model predicts that the vast majority of Balapan events were detonated in the sequence of Paleozoic sedimentary and volcanic rocks, while only a few were detonated in the underlying granite. The current model is consistent with the basic features of the geology at all six of the test locations recently published by the Soviets, in that the device emplacement points of all of these sites apparently lie in the sequence of Paleozoic sedimentary and volcanic rocks, and above the granite intrusions.

The model also shows a distinct difference between the northeastern and southwestern portions of the test site, as the granites are much closer to the surface and the alluvium thinner in the southwest. This is consistent with seismic analyses of explosions at the test site. However, the base of "real" data in the northeastern portion of the test site is much smaller than that for the southwest.

The videotape that accompanies this paper was selected by a jury from among 440 entries to the video showroom at the SIGGRAPH annual meeting in Las Vegas, Nevada (August 1991). The data on which the model is based have been integrated into the "Yield Estimation System" for the Balapan nuclear test site that was developed by the Systems, Science and Software Corporation for the Defense Advanced Research Projects Agency.

Display and Query of a "Near Real-Time" Hydrologic Alert Network

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Within the U.S. Geological Survey (USGS), an extensive hydrologic network exists to record and transmit currently sensed data to the Automated Data Processing System (ADAPS) on PRIME computers in District offices. For a given sampling site, data can be recorded by several hydrologic parameter codes for stage, streamflow, precipitation, specific conductance, or other characteristics. Data are transmitted by satellite, routed to the appropriate District office, and processed within ADAPS. Data that exceed predefined thresholds are flagged as "alert values." Knowledge of the current alert status at sampling sites within a State is of critical importance during floods, hurricanes, and other extreme hydrologic events.

A system of computer programs called Real-Time Mapping (RTMAP) was developed to provide interactive graphics display and query of those hydrologic data in a map-based, menu-driven environment. The programs were designed to be portable and require a minimum of installation effort. The RTMAP system is composed of two sets of computer programs, both of which reside on the two principal computer operating systems used by USGS Headquarters and field offices. One set of programs, written in Command Processing Language (CPL) and FORTRAN, retrieves data from ADAPS on the PRIME computer. Unit-values data are retrieved for those sites and parameter codes for which alert thresholds have been set within ADAPS. Under default conditions, data are retrieved within 15 minutes to 4 hours after being recorded, resulting in a "near real-time" data base. The data are transferred to a UNIX-based computer for all further processing and display.

A second set of programs, written in Arc Macro Language (AML) and FORTRAN, processes site-header information and unit-values data into an ARC/INFO point coverage and related files. The macro RTMAP.AML controls the menu-driven display and query of the data. Hydrologic sites are displayed on a State map and flagged according to their alert status. If a site code and an associated parameter code are selected, a time-series graph of the current value, and values from the previous 5-day period, can be drawn to the graphics screen. Plot files of the current map, graph, or entire graphics screen can be sent directly to a PostScript printer. Extensive additional functions are incorporated into the RTMAP graphics system that give the user a wide range of options for investigating the available data.

Use of Geographic Information System in Visualizing Spatial Data

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A Geographic Information System (GIS) was used to aid in the visualization of data collected as part of a study of seawater intrusion beneath the Oxnard Plain, 60 miles northwest of Los Angeles, California. This GIS data base includes information on well locations, pumpage, ground-water levels, ground-water quality, direct-current resistivity soundings, geology, soil types, land use, township and range boundaries, roads, and railroads.

In previous studies, on the basis of chloride concentrations in ground water, the extent of seawater intrusion was estimated to be about 23 square miles. Water-quality data collected and analyzed in 1991 as part of this study show that the areal extent of seawater intrusion had been overestimated; this analysis indicates that the extent of intrusion is 8 to 13 square miles. Sources of chloride to wells outside the area intruded by seawater include leakage of water from overlying aquifers through failed well casings and movement of water from ancient evaporite discharge zones within the Oxnard aquifer.

The ability, using the GIS, to display perspective views of interpreted direct-current resistivity soundings overlaid with information on well locations, water quality, land use, and soil types helped researchers to determine accurately the position of the seawater front and to identify sources of high-chloride water other than seawater beneath the Oxnard Plain.

Using a Microcomputer to Create an Animated Three-Dimensional Visualization of Bahia de Anasco, Puerto Rico

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The turbid waters of Bahia de Anasco off the west coast of Puerto Rico were studied to determine the effect of the discharge of primary treated sewage on the surrounding marine community. During the study, a sidescan-sonar mosaic was generated to precisely locate the sewage outfall in relation to reef building corals in the bay. Using the mosaic and bathymetry data as input, a three-dimensional animated visualization of the bay was produced on an 80486 Intel microcomputer.

The sonar image mosaic was created by towing a sidescan-sonar array in parallel passes through the waters of the study area. High-resolution single channel reflection seismic lines were collected at the same time as the sonar data. The sonar images were corrected for distortion, registered, and printed with a 8-bit resolution thermal printer. The printed sections of the tracks were pasted together to form a large mosaic and photographed. The seismic lines and the mosaic were used to create a bathymetric map of the study area.

AutoCAD (Autodesk, Inc.) computer aided design and drafting software with the Quicksurf (Schriber Instruments, Inc.) module was used to digitize the bathymetry and manipulate the data to generate a three-dimensional surface grid. A flatbed scanner was used to enter the sonar mosaic image to the microcomputer. Big D (Graphics Software, Inc.) rendering software was used to register and drape the sonar mosaic image over the three-dimensional grid and set the "camera" angles used in the visualization. The rendering software also generated the necessary frames between camera angles. Animator (Autodesk, Inc.) software was used to display the generated frames. The visualization was recorded to videotape using a VGA-TV (Willow, Inc.) graphics card and a 1/2 inch VHS videotape recorder.

The final product was a VHS format video of a fly-over of the three-dimensional model showing the location of the outfall, the coral reefs, sand channels, and muddy flats.

Using Visualization Tools at the U.S. Environmental Protection Agency Visualization Center

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The U.S. Environmental Protection Agency's (EPA) Scientific Visualization Center serves the EPA community of researchers spread over the United States and collaborates on inter-agency and university environmental research projects. Within EPA, there are a wide range of research interests. One group develops models for the transport and deposition of airborne pollutants used in the development of control strategies for the management of air pollution, such as the Clean Air Act. Another group is evaluating the positions of air quality monitoring sites with respect to the distribution of pollutants. Other researchers are collaborating with respective investigators at National Aeronautics and Space Administration Langley and Lawrence Livermore National Laboratory to examine global climate change. Still other scientists are studying water quality and sedimentation in the Great Lakes region; electrical properties of carcinogens, subsurface contamination of waste disposal sites, and the air flow through and around buildings.

This presentation will focus on the unique issues and problems associated with the visualization of these types of environmental data sets. A video *Environmental Visualizations* of visualization work completed at the EPA Scientific Visualization Center will be shown.

Characteristics of the Scientific Graphics Displayed by Three Computer Systems

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The Hydrologic Information Unit (HIU) is the focal point for reporting current hydrologic conditions for the U.S. Geological Survey (USGS). Some of the products include: the *National Water Conditions* (a monthly newsletter summarizing hydrologic conditions in the United States and southern Canada); reports to the Chief Hydrologist on current hydrologic conditions; press releases based on current hydrologic conditions; briefing statements and materials for congressional budget hearings; materials for briefing of Divisional, Bureau, and Departmental staff on hydrologic conditions; and other informative materials (using both electronic and print media) for both USGS Headquarters and field offices. The electronic products include personal computer/workstation displays of hydrologic information (streamflow, reservoir storage, and ground-water levels) on three computer systems -- Microsoft disk-operating system compatibles (MS-DOS), Apple Macintosh, and Data General UNIX -- currently in use by the USGS. Presenting virtually the same graphics on all three computer systems with a minimum amount of complete workup for each system requires relatively facile inter-system exchange of graphics. The graphics on all three computer systems include maps developed in the USGS Geographic Information System (GIS) on a PRIME minicomputer or data server (UNIX). Maps and chart-type graphics for the MS-DOS display were generated on PRIME minicomputers and captured as raster images. Maps for the Macintosh display were generated from the GIS PRIME or data server (UNIX) and captured as object-oriented graphics, and chart-type graphics were created using Macintosh spreadsheet/graphics programs and enhanced as necessary in object oriented graphics programs. Graphics for the UNIX system were derived from those generated for the Macintosh after conversion to computer graphics metafiles. Display software for the three computer systems differs greatly, both in the number of programs available or in general use for each system and the capabilities of those programs. Characteristics of the display software available for each system are discussed as well as techniques for creation, transfer, and display of informational hydrologic graphics.

GeoMedia: A Multimedia Educational System for Elementary School Children

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The U.S. Geological Survey is exploring the use of hypermedia technology for designing and developing computerized learning modules for the pre-college education community. Hypermedia or hypertext is defined as a software development environment for creating non-sequential data bases containing associative links between a mix of information, such as graphics, text, animation, sound, and video.

Research and developmental projects at a variety of universities have shown that this type of computerized information tool enhances understanding of complex scientific processes by focusing attention on the relationship between ideas rather than on isolated facts. The associations provided by linking graphics and animations to text and scientific data within a hypertext system may improve concept formation and understanding. The interactive nature of hypermedia may also contribute to its appeal to young learners much in the same way that computer video games have become so popular during the last decade.

A demonstration of the GeoMedia system will be given as part of the presentation. GeoMedia includes modules on the water cycle, understanding maps, and earthquakes. The multimedia system was created for children in grades 6-8 and operates on the Apple Macintosh II suite of computers. The system design of GeoMedia is based on scientific visualization of earth processes that relate to the water cycle, seismology, and cartography. Audio tracks are included to add another dimension to the visualization of earth processes. The effectiveness of scientific visualization as a teaching tool for middle school children will also be discussed.