

Evaluation of  
Precision Visual Workstation Analysis  
and Visualization Environment (PV-WAVE)  
Operating on a DEC Station 3100  
By Warren Garrett

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Approved by:

  
\_\_\_\_\_  
Garry D. McKenzie  
Advisor

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## **Thesis Statement**

The purpose of this study was to evaluate the capabilities of the Precision Visuals Workstation Analysis and Visualization Environment (PV-WAVE) software package operating on a Digital Equipment Corporation Workstation 3100, (DEC Station 3100) for application to the basic geomorphological techniques used to solve problems in geomorphological site analysis.

## Introduction

Three-dimensional visualization of the problems addressed in the geological sciences is crucial to the mastery of many of the concepts being taught there. Modern advances in geology and the theories behind them are requiring more and more visualization skills and techniques on the part of both students and faculty. In the academic world, computer graphics has long been an important tool used to approach the more complex problems. Students going on to graduate work in many areas in geology are already required to possess basic computer skills in order to continue their studies, and graduates from the undergraduate program will soon require them to function in the work place. A familiarization with computer graphics and the visualization skills learned along with that familiarization will better prepare both groups for their respective futures.

By using a computer system with graphics capabilities the student will benefit in several ways. The first is that through the use of three-dimensional projections of dynamic time-space relationships of earth processes, the student will more easily grasp the concepts of the exercises and be better able to apply those concepts to the solutions of related problems (1). Second, this visualization will greatly increase the instructional efficiency, allowing the student time to better understand the implications of the exercises and allowing the instructor time

to introduce new concepts (1). A third benefit to the student is that the exercises can be developed with initial input from the experts in each subspecialty within the geological sciences. This would allow a better integration of the subdisciplines toward the solution of the problems rather than relying heavily on concepts from one area and very little on concepts from other areas (1). In short, three dimensional visualization using computer graphics will allow the student to learn the concepts being taught easier, more efficiently and with a higher degree of integration of the separate subdisciplines in the geological sciences.

Geomorphology is the study of the form of the earth and its genesis (3). More specifically it is a science that deals with the land and submarine features of the earth's surface. It seeks a genetic interpretation of them through the use of the principles of physiography. In its explanatory aspects it uses the principles of dynamic and structural geology. Studies in geomorphology can be undertaken on many different scales such as world geomorphology, continental geomorphology, geomorphology of the ocean floor and areas of smaller dimensions such as the geomorphology of New Zealand or the British Isles (3).

The basic techniques in geomorphology are a combination of techniques used by physical geographers and geologists. They can be categorized under the main headings of field techniques, experiment and theory, cartographic and morphometric analysis,

sediment analysis and statistical analysis (3). The measurement and determination of many physical parameters and characteristics is a basic component of several of the techniques in geomorphology. These parameters and characteristics include but are not limited to: area, linear distances, elevation, stream gradients and profiles, landscape profiles and structural cross-sections. It is the determination of these and other parameters and characteristics that is the focus of this study. This study is basically an investigation of the hardware, software and steps necessary to calculate and determine the parameters and characteristics discussed above.

### **The System**

The three computers in the Geological Sciences Computing Laboratory that are available for use in the laboratory exercises in Geology and Mineralogy 550, are DEC Station 3100's. They are all linked to common data bases through the DEC System 5400 referred to as the **server**. The system has access to 16 megabytes of RAM at each DEC Station 3100, 32 megabytes in the server and 2.3 gigabytes of permanent disc space also in the server (5,7). The system uses UNIX as its disc operating system which among other things allows the user to operate either interactively or in batch mode (2). UNIX is a multitasking environment which can allow the user to run up to 52 separate

jobs at any given moment (2). All 52 can be accessed through the use of icon boxes that call up windows which display each job separately and allow the user to manipulate data that pertains to that job (2). Each window can have many widgets, or subwindows that assist in the management of operations in that window.

The display characteristics at each DEC Station 3100 are 1024 pixels across by 824 lines down, which is considered high resolution (7). When using PV-WAVE (Precision Visual Workstation Analysis and Visualization Environment) the DEC Station 3100 has the capability of producing 1 million different colors and displaying any 128 of them at once (7).

Data input can be from the keyboard by the user, from magnetic tape, or through Ethernet, a worldwide computer networking system (5,7). It can also accept digitized or ASCII characters as input from any of the above sources (5). Data output can be in either format as well and can be sent to the workstation screen, magnetic tape, computer disk, printer, plotter and the Tektronix terminal (5,7).

#### **Precision Visuals Workstation Analysis and Visualization Environment (PV-WAVE)**

In general, PV-WAVE is fast, easy to use and can easily be menu-driven. It contains both an on-line demonstration system and an on-line tutorial system (4,5,7).

PV-WAVE, as the name implies, is a visual (which is the graphics part) and analysis (which is the mathematical part) environment which allows the user to analyze his or her data and display the results of that analysis in a number of ways.

In data analysis the user has many options ranging from the basic arithmetic operations and absolute value, various roots, all the trigonometric functions etc., to the more complex operations such as evaluating polynomials, dealing with complex conjugates with imaginary components, vector analysis, multiple linear regression, etc. (5,6,7).

When displaying data, PV-WAVE provides a number of routines for plotting that allow relatively easy visualization of the data displayed without requiring the user to write extensive programs. Several examples follow and many more are possible (6,7).

#### X VERSUS Y PLOTTING ROUTINES

When using these routines it is possible display normal X,Y axis plots and also two dimensional representations of X,Y,Z axes. With these routines the user can:

- Draw annotated axes
- Overplot a given array onto another axis
- Plot an array on a new axis
- Change axis scales to:
  - linear, linear

-- linear, log  
-- log, linear  
-- log, log.

Some examples of the various displays that can be generated using these routines are contour plots, polar coordinates plots, elevation profiles, seismic data displays and histograms (6,7; see figs. 1-4).

#### TWO-DIMENSIONAL PLOTTING ROUTINES

When using these routines the user can get both two-dimensional plots and apparent three-dimensional images (5,7; see fig. 5). These apparent three-dimensional images can display normal two-dimensional cartesian coordinate data together with the third dimension, height or elevation and give an apparent three-dimensional image of the data. A fourth dimension can be added using various colors; for example, the different colors can indicate variations in snow depth at different locations in the image (5,7).

#### **Application**

Following are the major steps necessary to get the system operating at a level where some of the labs in Geology and Mineralogy 550 can be conducted using it.

The first step is to set up an account on the system for the

course. This creates a directory which can be divided into subdirectories as necessary for programs, data bases and output storage.

Next, digitized data bases should be entered into the appropriate subdirectories where they can later be accessed as required by the user. These data bases can be developed using the digitizing scanner in conjunction with a digitizing table or tablet, all of which are available in the Geological Sciences Computing Laboratory. Digitized data bases that are to be used for three dimensional imaging purposes cannot be generated with our existing equipment but they are available from the USGS or NASA, at reasonable rates.

The next step is to develop programs that will allow the student to run various PV-WAVE routines when desired through an interactive user interface to solve laboratory exercises. All of the mathematical functions and most of the routines are already part of PV-WAVE's programming and need only be called up as desired by the student using the interface. Analysis of map area, linear distances, elevation, gradients, volumes, landscape and stream profiles, etc., can be done easily this way.

The next step is to develop a user interface to essentially walk the student through all the steps necessary to accomplish the laboratory assignment. It should use menus the selections of which are accomplished by using the mouse. It will need to display instructions to the student on which menus to use, which

programs to run and prompt the student for data input when necessary.

An example of the above steps applied to a proposed exercise would be to compute the volume of water contained in a reservoir behind a dam. The student would access a data base in response to prompts to get an image of the area being studied. Then he or she would indicate the elevation height that the water would be allowed to rise to, and have PV-WAVE color all positions of the image below that elevation another color. Next, exclude the portions that won't be part of the reservoir, if any, and then compute the volume of the remaining portion of the image. The only programming necessary for this exercise will be the user interface that prompts the student for data and allows the student to make selections from menus.

Several other laboratory exercises using some of the basic techniques of geomorphology require more programming and user interaction to accomplish than the above example. Some of these are: analysis of simple structure cross-sections using bore-hole data, analysis of earth processes whose effects vary with time, and using the remote sensing capabilities of PV-WAVE. An example of a laboratory exercise using an earth process whose effects vary with time would be erosion/ deposition studies. The effectiveness of this exercise would increase with the number of time-lapse images of the area. Once the images were digitized and entered into the system, the necessary programs and interface

could be developed to select the various routines in PV-WAVE in the proper order which would access the data bases and display them sequentially at the desired frequency.

The examples above are meant to illustrate the level of user interaction required, the amount of programing that will be necessary and the assumed level of user computer knowledge. When the data bases are digitized and installed and the programs and interface are written, the student will be required to log onto the system and access the Geology and Mineralogy 550 laboratory directory. From that point the interface will be able to prompt the student for information and selections from menus. This assumed level of user computer knowledge is necessary to minimize the amount of class time spent on learning to operate the system. Further computer skills could be taught as part of the laboratory exercises. This approach will allow the student to accomplish more exercises while focusing more on the concepts behind them rather than on the mechanics of calculations.

### **Foreseeable Problems**

At present the Geology and Mineralogy Department does not possess the required digitized data bases and would be required to obtain them. This could be accomplished by purchasing them or generating them from photographs or maps.

Generating them can be done from within the Geological

Sciences Computing Laboratory but only for two-dimensional imaging applications. This is accomplished by the use of the digitizing scanner which works on the same principle as a photocopier. It scans the image, digitizes the different light intensities, and transfers the information to the DEC Station 3100. With the map or photo in the computer one can use a digitizing table to enter geological features into the database (faults, glacial deposits, shorelines, etc.)

For applications requiring three-dimensional display it would be necessary to purchase data bases from USGS or NASA. One advantage to purchasing them is that you can get data from exotic locations on earth and from other planets as well.

When developing exercises using PV-WAVE's remote sensing capabilities the programing will necessarily be more lengthy because PV-WAVE requires more user interaction when using the remote sensing capabilities and a better understanding of PV-WAVE itself than is generally required to use the other system capabilities.

This project will require one person who is a programmer that can remain on it from start to finish. This will be necessary to insure continuity of the entire project and to obtain useable results. It would be a more efficient use of time also because it takes a considerable amount of time to learn PV-WAVE well enough to program in it. Changing programmers in the middle of the project would represent a loss of that time.

The person selected for the project should be a geomorphologist, or very familiar with geomorphology and in close contact with a geomorphologist.

### **Summary**

The importance of using computer graphics and three dimensional visualization in teaching undergraduate students the concepts of geomorphology cannot be overstressed. Computer-aided three-dimensional visualization will better prepare the students for the work place and further studies in their field by allowing easier assimilation of the concepts covered, by contributing to the more efficient use of class time allowing the instructor to cover more concepts, and by allowing a better integration of the subdisciplines in the geological sciences.

The basic techniques used in geomorphological studies can be accomplished through the determination of many different physical parameters which can be easily determined using the DEC Station 3100 and PV-WAVE, a computer graphics software package that the Geological Sciences Computing Laboratory has.

The system as it currently exists consists of three DEC Station 3100's and a DEC System 5400 which links the three DEC Station 3100's into a network and also supplies up to 2.3 gigabytes of permanent disk storage space. The system uses the UNIX disk operating system which allows the user a high degree of

flexibility and the ability to run up to 52 separate jobs at one time accessed through windows. Each window can have several widgets or subwindows as well. The system has a high resolution display and can take input from several sources in ASCII characters or digitized format.

The software package, Precision Visuals Workstation Analysis and Visualization Environment (PV-WAVE) can be menu-driven and has on-line demonstration and tutorial systems. Output can be obtained using a variety of devices. Mathematically, PV-WAVE can accomplish any calculations required in a geomorphology laboratory assignment. The data can be displayed in a variety of ways including two-dimensional representations of two and three axis graphs, two-dimensional plots and apparent three-dimensional images with as many as four dimensions represented. To use the system in the geomorphology laboratory assignments the following steps will be required:

- Set up an account on the system for Geology and Mineralogy 550.
- Obtain and enter the desired digitized data bases into the appropriate subdirectories.
- Write the necessary programs and create an interface which will allow the student to run the various PV-WAVE routines.

Some of the basic techniques in geomorphology can be accomplished on the computer with less programming effort than others but the

majority of them can be done using programs that already exist within PV-WAVE.

The most significant obstacle for this project is that it will require the services of an experienced programmer for the duration of the development of it and that is estimated to be approximately one year, with a graduate student with other duties and an academic load. A lesser obstacle is the acquisition of the required three-dimensional data bases. They can be purchased and are readily available through the USGS and NASA at reasonable rates.

This project can be accomplished with the existing equipment and software with a reasonable amount of effort and expense. Since the hardware and software are already in possession of the department the only additional expenses will be for the programmer and a few digitized data bases.

#### **Suggestions For Future Development**

The remote sensing capabilities of PV-WAVE require the user to interact more with the system than the other system capabilities do. If these capabilities are to be used in the geomorphology laboratory assignments it will be necessary to write longer programs and they will require a more complicated user interface. These capabilities can be very useful in geomorphology in conducting time studies such as stream erosion,

delta evolution, river flooding and stream-bed shifting studies. These studies can be added to the project once the more basic functions of the programing have been accomplished and the system is operational. This priority system will allow the project to be operational at a reasonable level in the shortest possible time span. Once it is operational, then it can expand or proceed at whatever pace is desired.

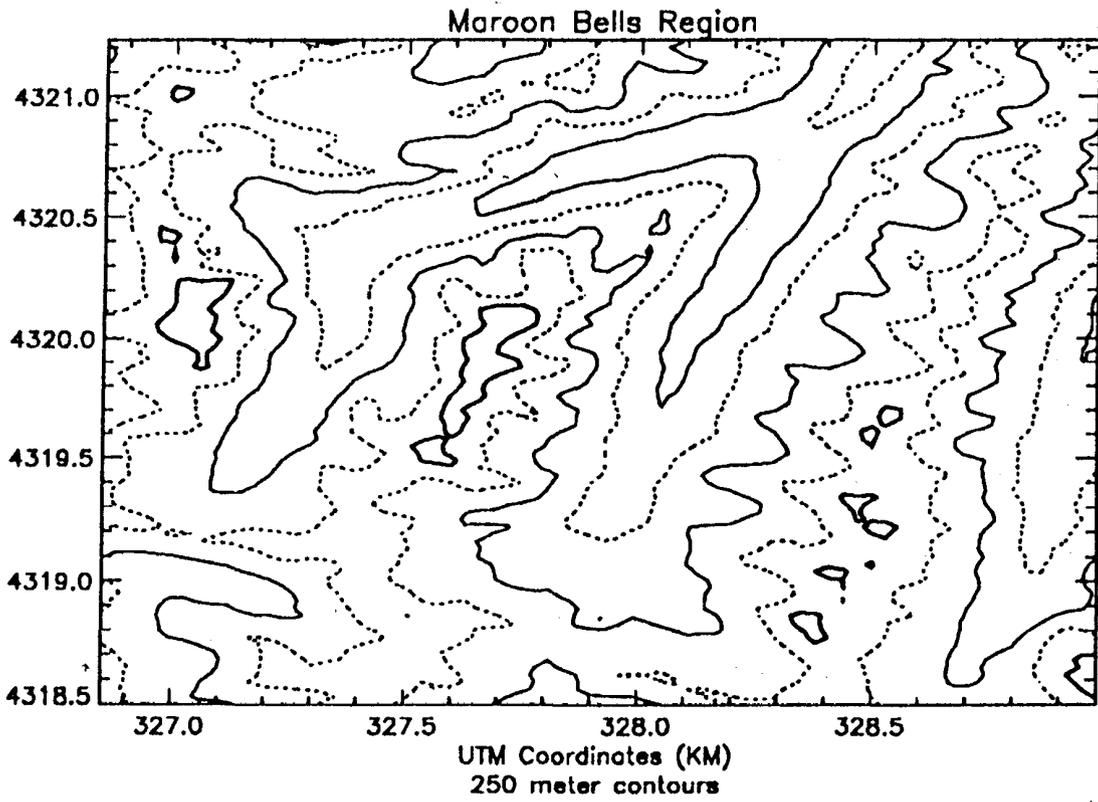


Figure 1. Example Contour Plot.

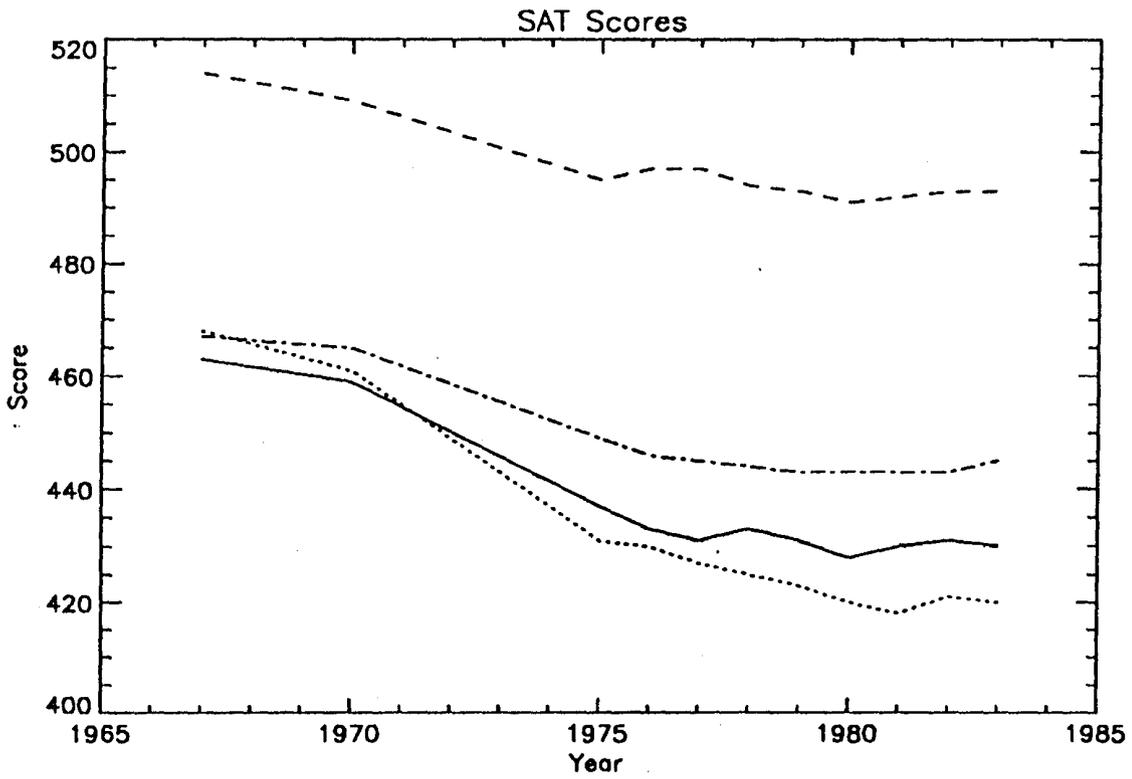


Figure 2. Example overplot.

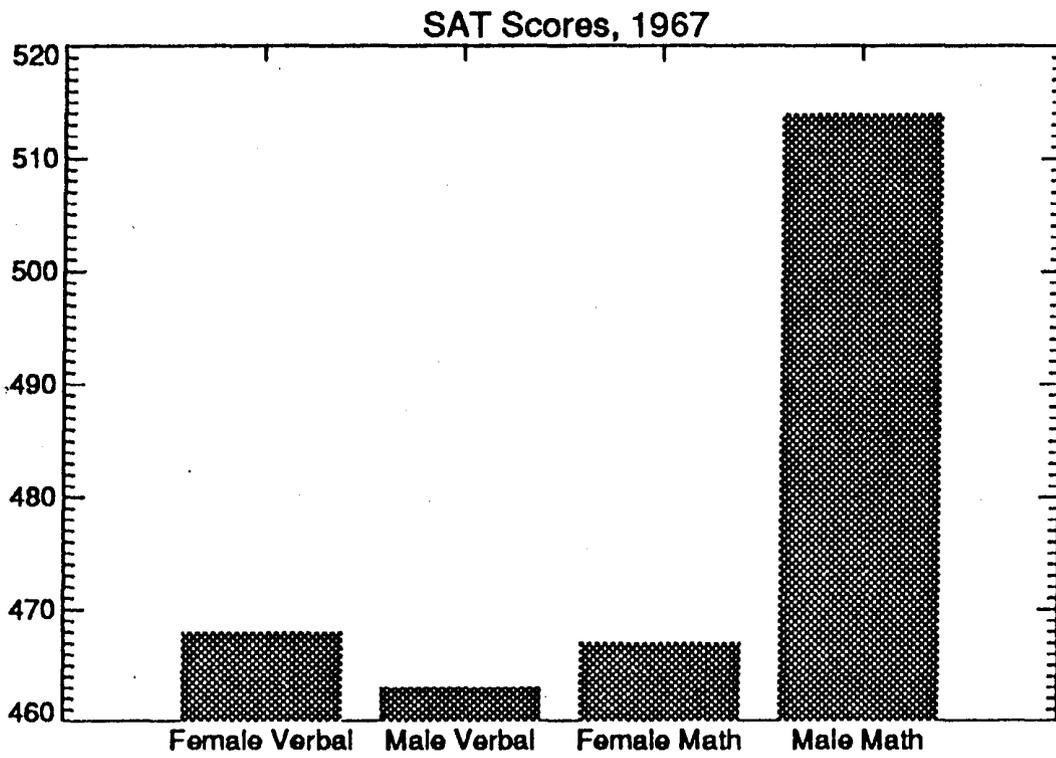
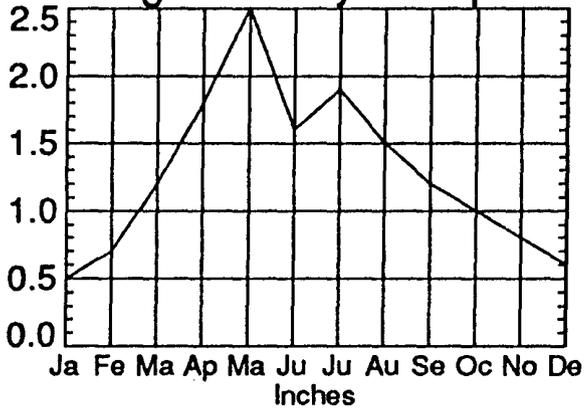


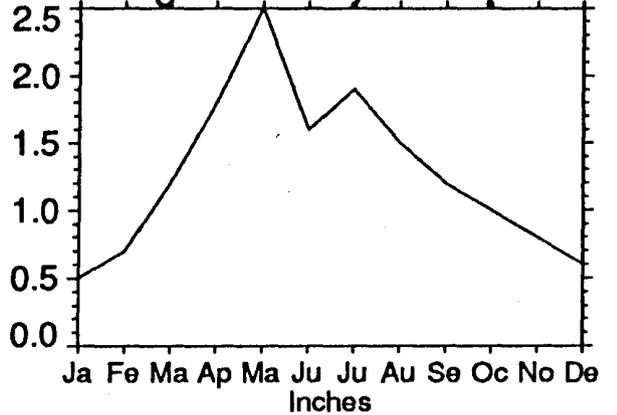
Figure 3. Example Histogram.

Average Monthly Precipitation

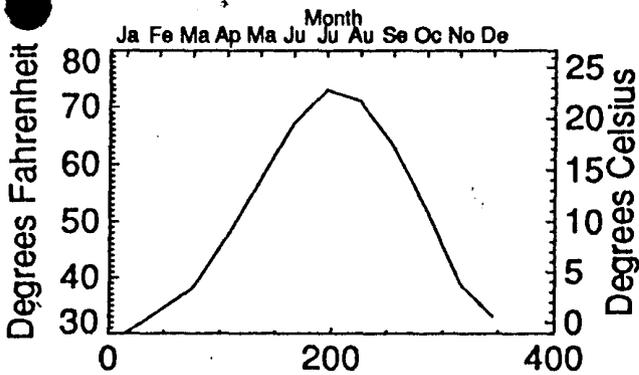


Denver

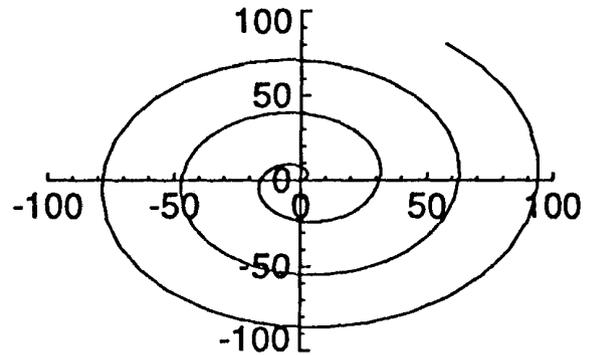
Average Monthly Precipitation



Denver



Denver Average Temperature



Polar Plot

Figure 4. Examples of Annotated axes and polar plot.

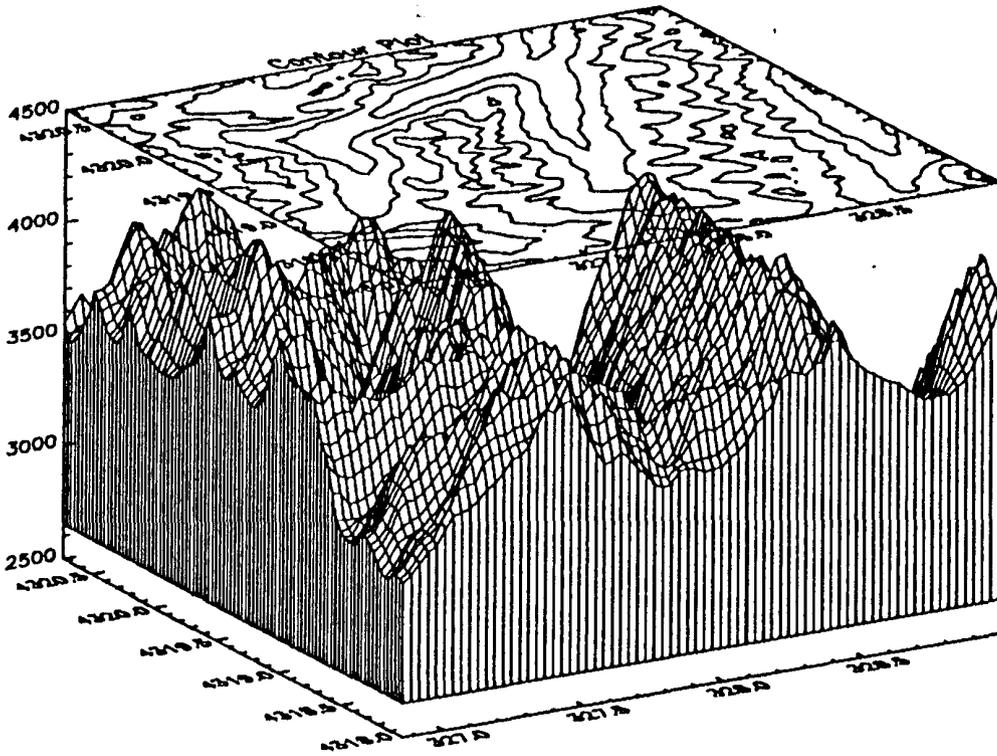


Figure 5. Example of apparent three-dimensional image.

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